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Test Driving an Elegant Dobsonian

The Biology of Star Trek

Deciphering the Surfaces of Venus and Mars

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MEA

LXD 300

Now you can buy a Meade® 8" f/10 Schmidt-Cassegrain Telescope, complete with equatorial mount, rigid full-length aluminum tripod, and accessories for only $795! Or a Meade 4" f/9 Achromatic Refractor, complete, for only $595!

Never before have Meade telescopes at these levels of optical and mechanical specifications been available at such low prices. And yet, both instruments are ready for a lifetime of exciting photo-visual applications.

- **Optical Systems:** The Meade 203SC/300 includes the exact same optical tube assembly as more expensive Meade 8" Schmidt-Cassegrains, a diffraction-limited optical system that is, by far, the largest-selling in the world in its aperture class. Model 102ACHR/300 includes the exquisite Meade 4" air-spaced achromatic lens, corrected for spherical and chromatic aberrations. All 4" and 8" optics are EMC super multi-coated for maximum light transmission.

- **LXD 300 Equatorial Mount:** The high-performance Meade LXD 300 equatorial mount, with dual-axis aluminum worm gears, micrometric slow-motion controls, setting circles, and fine-adjust azimuth and elevation controls, provides an exceptionally strong, steady platform for Meade 4" and 8" models.

- **Observing Applications:** Meade 300-Series models permit an extremely wide array of photographic and visual observing opportunities, including astrophotography of the Moon and planets and even limited deep-space photography.

SPECIFICATIONS: Models 203SC/300 and 102ACHR/300 — Each telescope includes 8" f/10 Schmidt-Cassegrain *or* 4" f/9 Achromatic Refractor optical tube assembly with EMC super multi-coatings; LXD 300 equatorial mount with aluminum worm gears, micrometric manual slow-motion controls, and setting circles on both axes; manual control for azimuth alignment; elevation control and scale for polar alignment at latitudes from 15° to 50°; adjustable full-length aluminum tripod with bubble level and accessory shelf; 6 x 30mm achromatic viewfinder; eyepiece-holder (1.25"); #918A diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece (203SC) *or* Series 3000 Plössl 25mm eyepiece (102ACHR); provision for addition of optional #812 Polar Alignment Finder; operating instructions.

#535 R.A. Motor Drive System	**$99**
#812 Polar Alignment Finder	**49**

MEADE 203/SC EMC
LXD 300

Model 203SC/300: 8" f/10 Schmidt-Cassegrain Telescope

$795

(+ $65 packing and shipping in the 48 states)

Model 102ACHR/300: 4" f/9 Achromatic Refracting Telescope

$595

(+ $55 P & S)

Prices listed are suggested U.S. national mail-order retail prices.

ADE

LXD 500

For even broader capability, use the Meade® high-precision LXD 500 equatorial mounting, with dual-axis bronze worm gears — the finest equatorial mounting available in its price class.

Manufactured to exclusive Meade standards of precision, the Meade LXD 500 equatorial mount is 20% larger than the LXD 300 mount and permits applications of the telescope, in conjunction with the optional 4-speed #1702 Dual-Axis Drive System, that include long-exposure deep-space astrophotography. Engraved setting circles on both axes allow for the location of faint objects directly from their catalogued coordinates.

Incorporating the same optical tube assemblies as the 300-Series, Meade 500-Series models offer a level of mechanical precision generally available only on telescopes costing hundreds of dollars more.

SPECIFICATIONS: Models 203SC/500 and 102ACHR/500— Each telescope includes 8" f/10 Schmidt-Cassegrain *or* 4" f/9 Achromatic Refractor optical tube assembly with EMC super multi-coatings; LXD 500 equatorial mount with oversize bearings, high-precision bronze worm gears, micrometric manual slow-motion controls, and setting circles on both axes; manual control for azimuth alignment; elevation control and scale for polar alignment at latitudes from 15° to 60°; adjustable full-length aluminum tripod with bubble level and accessory shelf; 6 x 30mm achromatic viewfinder; eyepiece-holder (1.25"); #918A diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece (203SC) *or* Series 3000 Plössl 25mm eyepiece (102ACHR); provision for addition of optional #812 Polar Alignment Finder; operating instructions.

#1701 R.A. Motor Drive System, with 4-speed controller	$145
#1702 Dual-Axis Drive System, with 4-speed controller	195
#812 Polar Alignment Finder	49

For details on the full range of Meade astronomical telescopes, CCD imagers, and accessories, call, write, or fax for your free copy of the Meade 100-page General Catalog.

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"DPM Library"

Model 203SC/500: 8" f/10 Schmidt-Cassegrain Telescope

(shown with optional #1702 Drive System)

$895

(+ $65 P & S)

Model 102ACHR/500: 4" f/9 Achromatic Refracting Telescope

$695

(+ $55 P & S)

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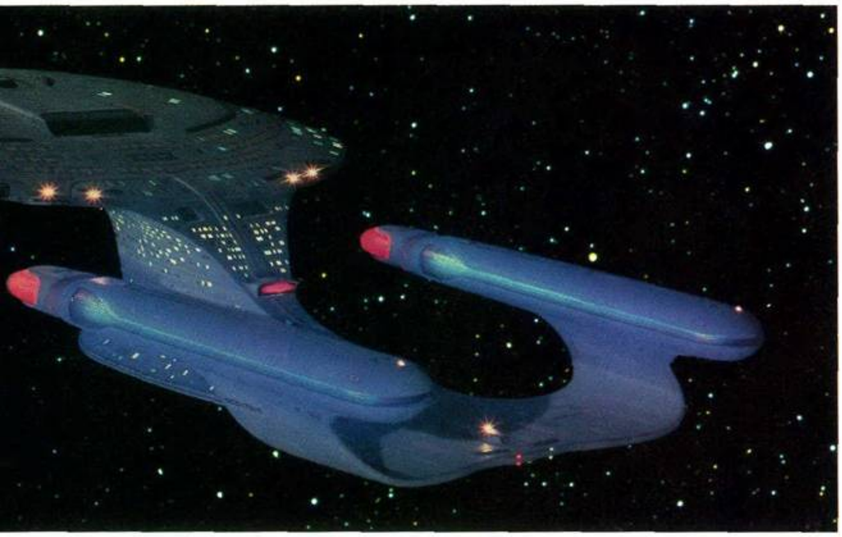

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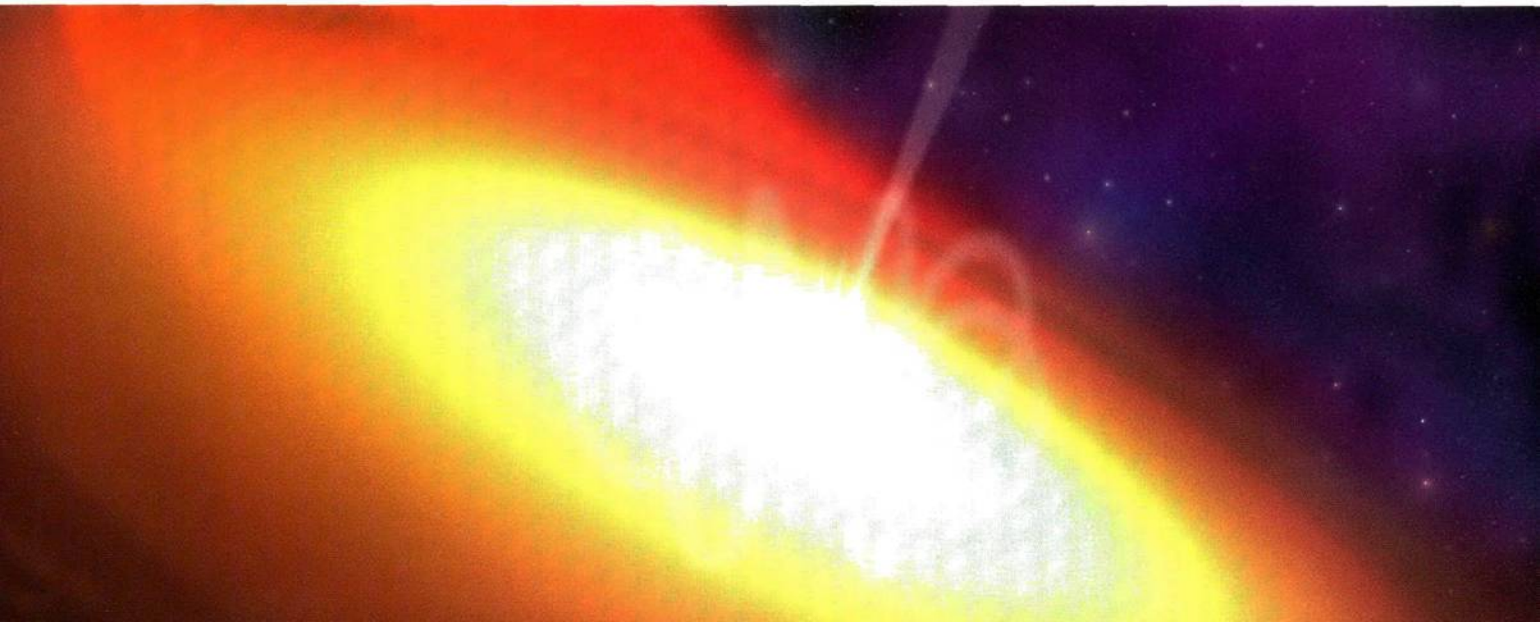

BEHIND THE SCENES

BY BONNIE BILYEU GORDON

1999: A Big Year for Launches

In the 1950s, space stations were pure fiction. By the time you read this, Earth's second space station will be under construction — in space. In addition to the two chunks that should already be up, seven launches scheduled for 1999 should put many more components of the International Space Station into space. The grand scheme calls for completion of the station by 2004. There is reason to hope the station foreshadows space adventures that only novelists have imagined until now.

While scientific research is planned for the station once it is complete, many other 1999 NASA missions will move more quickly to break down knowledge barriers. Several smaller (cheaper) missions will launch telescopes that will measure light humans can't see. Others will get very personal with Mars.

Two missions will set off in January: The first, a Mars Polar Lander, will make a soft landing on Mars near the edge of the South Polar ice cap. When it touches down in martian summer, the lander will study Mars with cameras, a robotic arm, and devices to analyze the soil. To get deeper into Mars, NASA is sending two basketball-sized "aeroshells" with the lander. The balls will crash on the planet in December 1999, releasing probes that will bore into the soil looking for signs of water and life. The lander's partner, the Mars Climate Orbiter, was launched in 1998 to get a broader view. Though launched two years ago, the NEAR asteroid chaser should arrive at its target, Eros, in January and begin to orbit. We haven't been so close to an asteroid before.

Stardust is scheduled to leave Earth in February, in an effort to collect interstellar and comet dust and be the first mission to return to Earth from beyond the moon with samples in tow.

In March, the Untraviolet Spectroscopic Explorer will go in search of light waves that should tell us more about quasars, massive stars, and supernovae. NASA will launch the Wide-Field Infrared Explorer that will look for clues to the secrets of starburst galaxies. And the third of NASA's (four) Great Observatories, the Advanced X-Ray Astrophysics Facility, will be launched. It will orbit Earth looking at hot turbulent regions where X rays are produced.

In upcoming months, *Astronomy* will take closer looks at many of these missions and also keep you informed about progress on the Next Generation Space Telescope, which may replace Hubble in the next decade. Because Hubble so broadened our view from Earth, we expect even more amazing things from the next orbiting optical telescope. But you can never tell what will bring in the most fantastic news. In 1997 an infrared camera was added to Hubble. Recent front-page newspaper stories (and Astronews, page 24) herald distant galaxies found by that add-on — way beyond those that Hubble has seen optically. The edge of our universe always seems to be slipping away.

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Diffraction-limited imaging and ultraportability ...at only $595, complete!

ETX Astro Telescope mounted on optional Field Tripod.

The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

SPECIFICATIONS: ETX Astro Telescope — Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. Net weight 9 lbs.

$595 (+ $20 packing & shipping in the 48 states)

ETX Field Tripod — The rigid, full-length ETX Field Tripod allows for seated or standing observations through the telescope; tripod height is adjustable from 34" to 54". Micrometric controls in both azimuth and elevation-angle permit precise polar alignment of the telescope's fork mount for astronomical applications. For terrestrial observing, where altazimuth orientation is desirable, the tripod head tilts to 90°. The telescope attaches to the tripod in seconds with two thumbscrews. Net weight 11 lbs.

$169 (+ $10 packing & shipping in the 48 states)

Tilt and lock the ETX Field Tripod to 90° for terrestrial observing.

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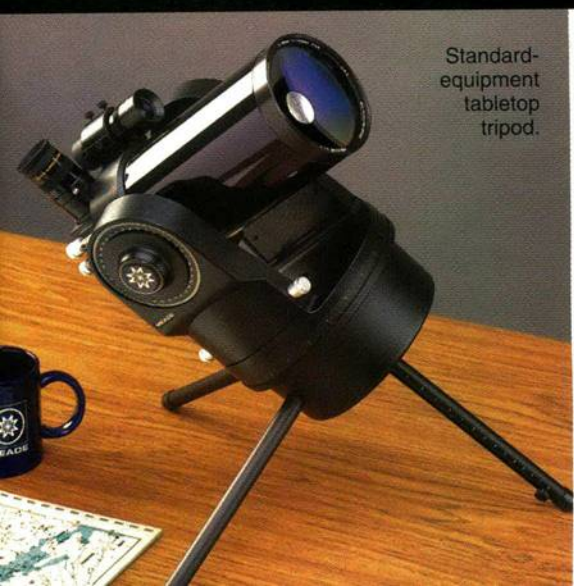
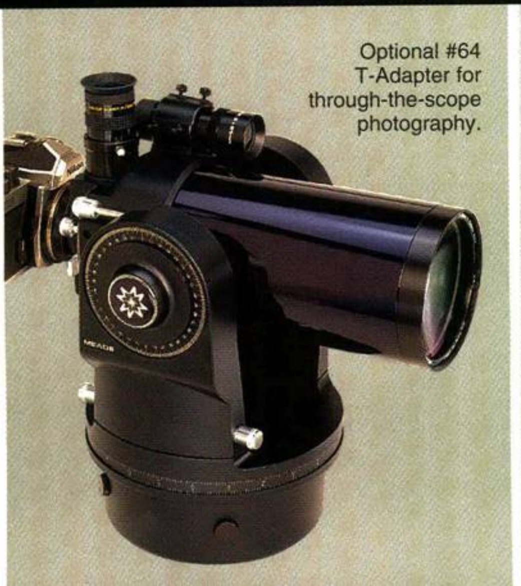


Standard-equipment tabletop tripod.



Optional #64 T-Adapter for through-the-scope photography.

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Orders & Information: 416-787-4581.

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Orders & Information: 416-783-4140.

MEADE LX50

Advanced technology at the most affordable prices *ever.*

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photoguide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*. A North-South switch permits telescope operation anywhere in the world.

- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

- **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

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MAGELLAN II
COMPUTER-CORRECTOR
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only $495!

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y	**1295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

MEADE LX50 EMC
7"
10"
8"

MEADE LX200

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

MEADE LX200 EMC
MEADE LX200 EMC
MEADE LX200 EMC
MEADE LX200 EMC
8"
7"
10"
12"
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MEADE STARFINDER DOBSONIANS

Now with Series 4000 Super Plössl 26mm eyepiece as *standard equipment!* Consider these features:

Series 4000 SP26mm Eyepiece (1.25"): The premium SP26mm ocular permits all Meade Starfinder Dobsonians to perform absolutely to their maximum capabilities. This $80 eyepiece is now **standard-equipment** on all Meade Dobsonians.

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: The same strong, spiral-wound Sonotubes™ used on Starfinder Equatorials *(right)*, tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

$270 Dobsonian Deluxe Accessory Package...only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- 1 - **Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- 1 - **Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- 2 - **Meade Series 4000 Super Plössl 9.7mm and 26mm** multi-coated eyepieces — premium-grade eyepieces for high-resolution lunar, planetary, and deep-space observing. *(reg. $79.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $269.80!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

MEADE
ENTER
MODE
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NEXT
ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

#2010: for Meade Starfinder Dobsonian 6", 8", 10", 12.5", or 16" . . . . $295.

Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES

Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.

All Starfinder Dobsonian and Equatorial models now with
Series 4000 Super Plössl 26mm
eyepiece as standard equipment!

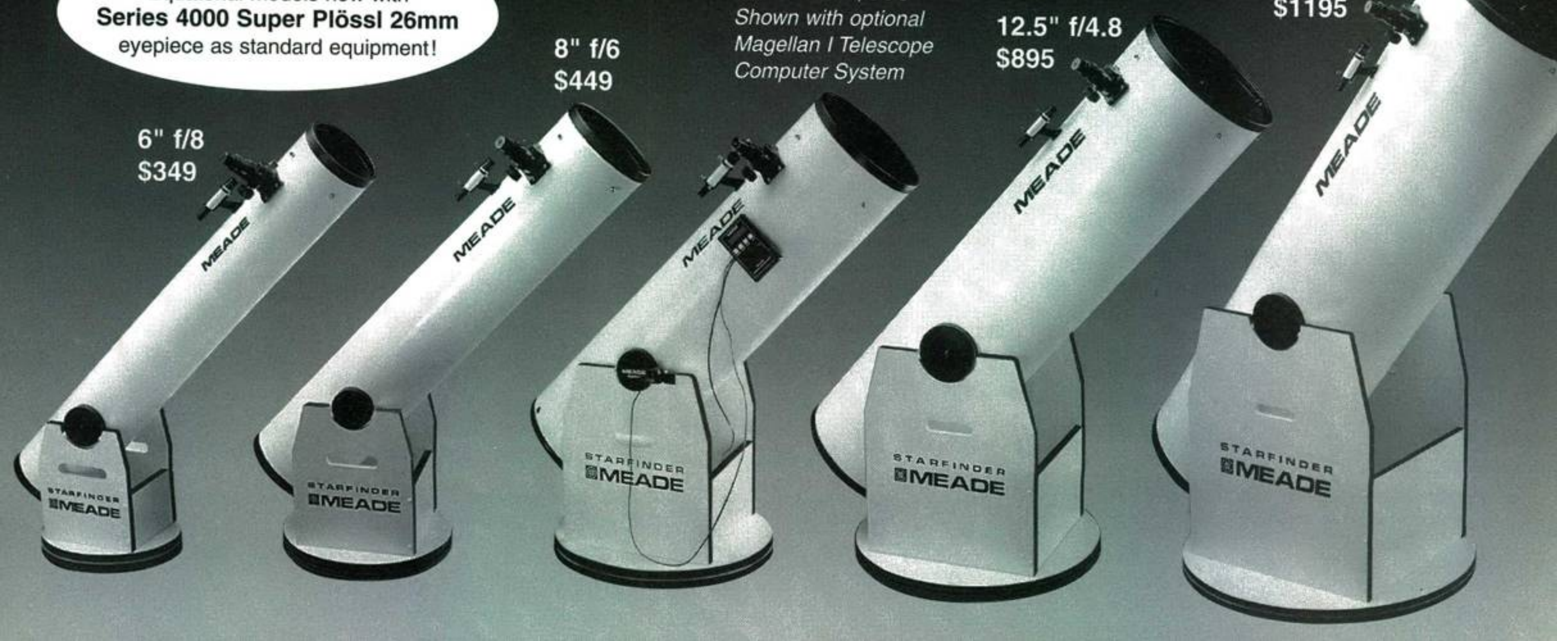
6" f/8 $349

8" f/6 $449

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12.5" f/4.8 $895

16" f/4.5 $1195



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STARFINDER EQUATORIALS

With DC-powered drive systems for automatic tracking and Series 4000 Super Plössl 26mm eyepiece.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); #637 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

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Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

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Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page)*.

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

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Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*

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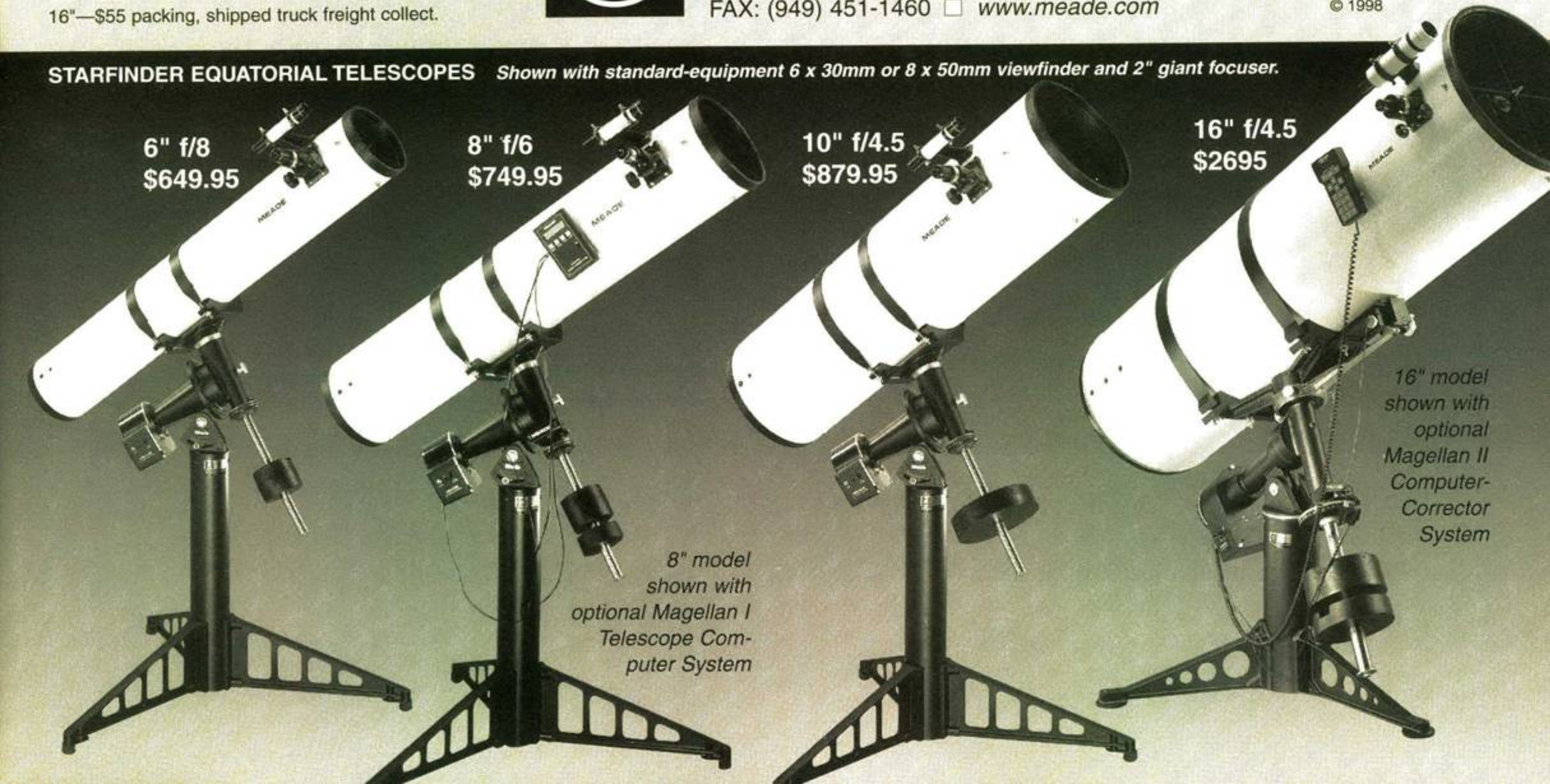
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



6" f/8
$649.95

8" f/6
$749.95

10" f/4.5
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16" f/4.5
$2695

8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

8" LX10

8" LX10 DELUXE

The optical performance of a Meade 8" LX200 Schmidt-Cassegrain...for only *$995!*

8" LX10: For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard-equipment includes:*

Super-Multi-Coated Optical System: The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. **Series 4000 SP26mm eyepiece:** Complements the exquisite imaging of Meade 8" SC optics. **Equatorial Fork Mounting:** The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. **Cordless, DC-Powered Electronic Motor Drive:** With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours. **Worm-Gear System:** The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging. **Hand Controller:** Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions. **$995.** (+ $65 packing & shipping in the 48 states)

8" LX10 Deluxe: At only $1149 the 8" LX10 Deluxe includes (a) the large-aperture Meade #544 8 x 50mm viewfinder (in place of the standard 6 x 30mm finder); (b) the LX10 Electric Declination Motor System, permitting dual-axis guiding corrections at 2x speed; and (c) Meade Epoch 2000 Jr. Sky Software with 10,000-object database — all at substantially lower cost than if the respective accessories were purchased separately.

SPECIFICATIONS: 8" Model LX10 Deluxe — Identical in all specifications to 8" Model LX10, above, but with Electric Declination Motor System provided as standard equipment, permitting dual-axis corrections at 2x speed; Meade #544 8 x 50mm achromatic viewfinder in place of 6 x 30mm viewfinder; and Meade Epoch 2000 Jr. Sky Software with 10,000-object database.

$1149. (+ $65 packing & shipping in the 48 states)

Field Tripod for LX10 or LX10 Deluxe	**195.**
Electric Declination Motor System for LX10	**95.**
#2014 Magellan I Telescope Computer System for LX10 or LX10 Deluxe, with 12,218-object database	**375.**

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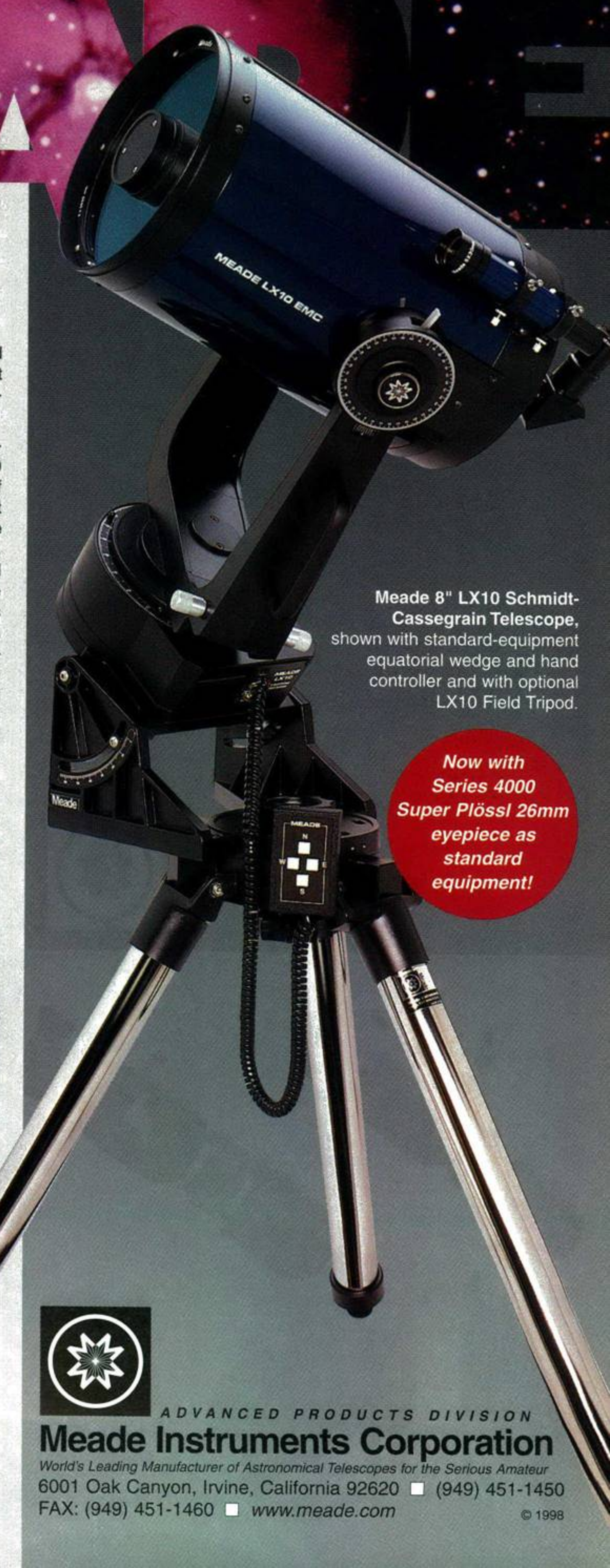

Meade 8" LX10 Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

Now with Series 4000 Super Plössl 26mm eyepiece as standard equipment!

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MEADE RESEARCH-GRADE ACCESSORIES

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **$79.95** (5.26)

Series 4000™ Super Plössls 52° field; multi-coated

Meade 4-element *Super Plössls*, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):
6.4, 9.7, 12.4, 15, 20, 26mm each: **$79.95** (4.54)
32mm (52°); **40mm** (44°) each: **99.95** (5.26)
56mm (52°; 2") **199.95** (7.02)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

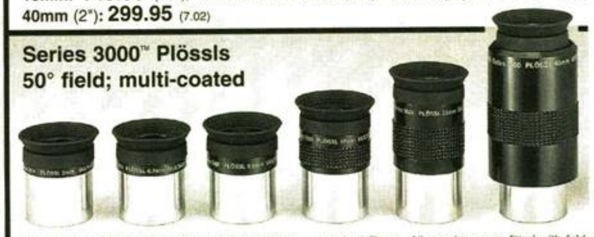
Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25". **$149.95** (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$129.95** (5.26)

Series 3000™ Plössls 50° field; multi-coated



Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A **49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A **49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56 **49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#911B
#910B
#908B

#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia. **79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia. **119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia. **89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia. **129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **119.95** (5.26)

#911X
New!
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia. **99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia. **159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.** each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

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2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25". **$59.95** (4.54)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera. **$39.95** (3.86)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (6.85)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera. **$39.95** (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera. **$26.95** (3.86)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces). **$42.95** (3.86)

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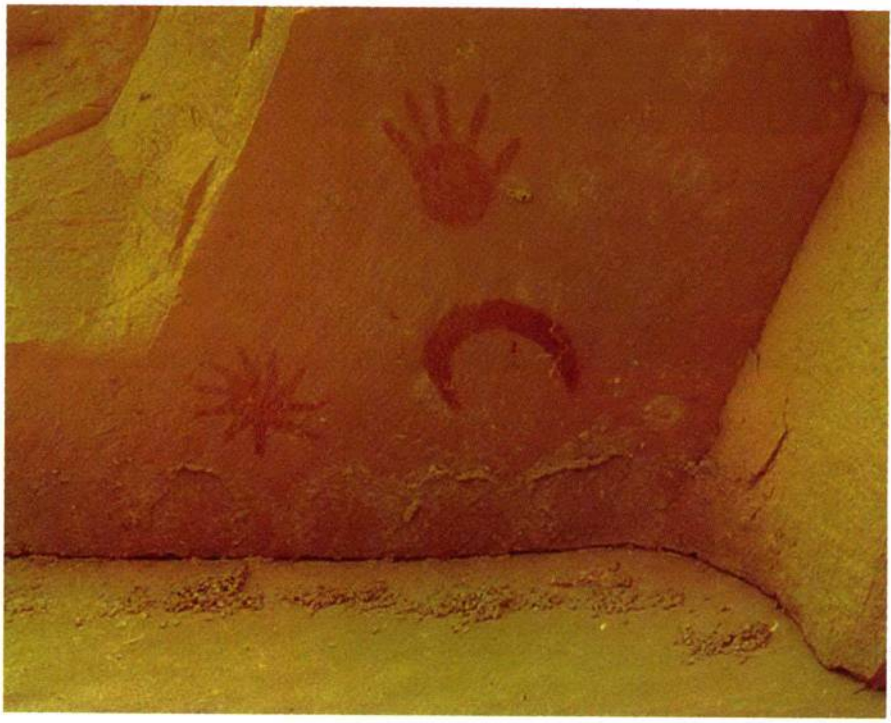
Right-Handed Artist Discovered

Astronomy flew Barry Hirrell and me from San Francisco, California, to Albuquerque, New Mexico, for a June 25, 1998, star party celebrating the magazine's 25th anniversary. Under a tent, in Rio Rancho Balloon Park, as the dust and wind whipped around us, we made a sun telescope. The next morning we delivered the finished telescope to a lady who had won it in a raffle.

After the star party, a New Mexico friend, Lisa Wood, and I drove to Chaco Canyon National Historical Park in northwest New Mexico. Park Ranger G. B. Cornucopia led Lisa and me on a sunny, six-mile walk, with temperatures in the high 90s, to a famous east-facing cliff. About 25 feet above ground-level is a rust-colored pictograph, or rock painting made centuries ago with an iron-oxide solution. The pictograph is painted on the protected, downward-facing surface of a ledge that projects from the cliff.

I am writing because a photograph of that pictograph was published in the November issue of *Astronomy*. It is a lovely image of the crescent moon, a bright star, and a hand. The star is thought by many to depict the supernova of 1054 AD However, the picture of the pictograph in the magazine is a mirror image of the actual pictograph. Facing the cliff and looking up, the star is left of the crescent. The published picture also shows a right hand, not a left hand, which actually is painted on the rock. I asked Ranger Cornucopia why the left hand, rather than the right, had been painted. He said, "She painted it with her right." — *John Dobson, San Francisco, California*



Ron Lussier

On July 4, 1054, an object brighter than the brightest star, flashed near the crescent moon. An Anasazi artist in what is now New Mexico painted the star, the crescent, and her left hand.

The Stellafane Effect

In July 1999, I attended my first Stellafane star party, the original telescope-makers' convention, near Springfield, Vermont. I entered a telescope my father built in 1952, a 12.5-inch f/8 half-open-strut Newtonian on a German equatorial mount.

Although I didn't win, many telescope builders were impressed by my father's scope, whose polar bearing is a salvaged Mack truck wheel hub. The telescope was dubbed "The little Hooker," after the 100-inch Hooker Telescope that Edwin Hubble used decades ago to discover that the universe is expanding.

The weather was cooperative, and as I wandered Breezy Hill I felt the presence of something ... perhaps the life force of all the dedicated amateur astronomers who have made Stellafane one of the largest star parties in North America. — *Jeffrey A. Hines, East Hampton, New York*

Greatest Discoveries Errata

The "Look Back" feature in the October issue that listed your picks of the 25 greatest astronomy findings of all time rightly notes that William Herschel discovered Uranus in 1781. But you could add an asterisk because of several famous mistakes that predated his discovery.

John Flamsteed spotted Uranus in 1690 and erroneously called it a 5th magnitude star. He listed the star in his atlas. Later, astronomer Joseph Jerome Lefranais de Lelande added to the confusion by designating Flamsteed's star 34 Tauri. (Of course, 34 Tauri later was omitted from charts.)

John Bevis, working on an atlas of his own in 1738, used Flamsteed's atlas as a guide and included 34 Tauri without doing his homework. Had Bevis looked for himself, he would have noticed that the star was not where Flamsteed said it was.

Furthermore, at the time the object was passing in front of what we now know as M22, an impressive globular cluster. In his atlas, Bevis mistakenly listed both the planet and the globular

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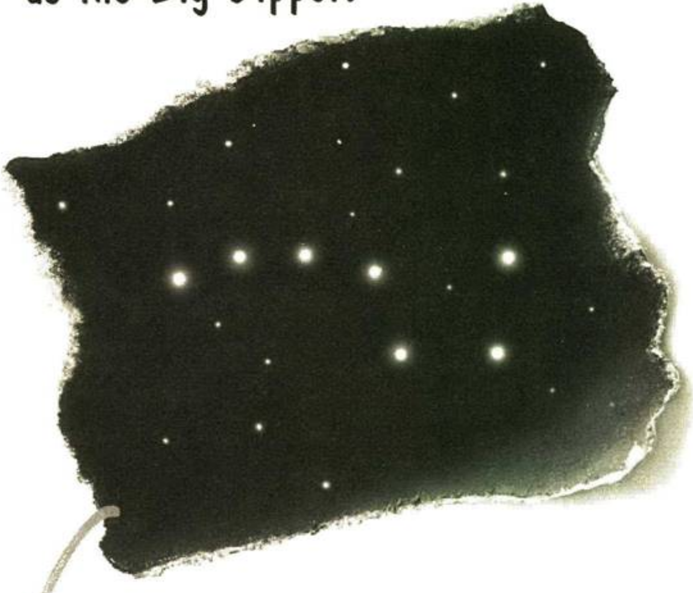

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cluster as stars. — *P.A. de Blois, Vancouver, Canada*

It was hard for me to understand why the discovery of Comet Shoemaker-Levy 9 was not among the 25 greatest astronomy findings in October's "Look Back" feature. — *Henry Kuhlman, Collegedale, Tennessee*

We live in an age of lists. *Astronomy*'s A-list of the "25 greatest findings of all time" was provocative. It challenged me to think about what my list would include. In doing so, I was struck by what I would consider two oddities. Can the discoveries of Pluto and the Tunguska meteorite truly be among the 25 greatest discoveries?

The list also is described as the "greatest findings" and "big discoveries." Findings are the result of an investigation, while discovery connotes an empirical observation.

This led me to wonder why 12 of your greatest findings were made in the 20th century and none before Copernicus. I offer, for example, Thales's prediction of a solar eclipse in 585 B.C. ... — *Jerry Cromwell, Sherborn, Massachusetts*

One-Piece Puzzler

The profile on University of Arizona astronomer Roger Angel ("Astronomy's Archangel') in the November issue made me wonder if there might be a way to launch Angel's one-piece mirror in NASA's Next Generation Space Telescope.

If the mirror was tipped on its side and fitted inside a saucer-shaped housing, the edges of the mirror would then protrude like stubby wings, but it would not add appreciable drag. The challenge would then be robotically assembling the housing and positioning the secondary mirror, but at least a one-piece, eight-meter mirror could be launched. — *Frederick Thurber, South Dartmouth, Massachusetts*

Yes, there are a lot of alternatives short of cutting the mirror into pedals. You could make the mirror elliptical, put it on its side, and fly it on a smaller-diameter rocket. If you have a 4-meter-capable rocket you could make a 4-by-8-meter mirror. But the secondary mirror would have to be collapsed,

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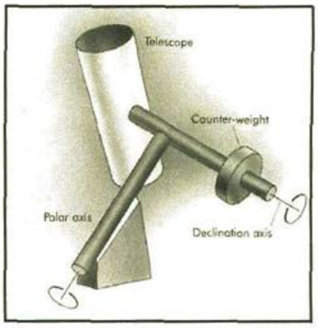
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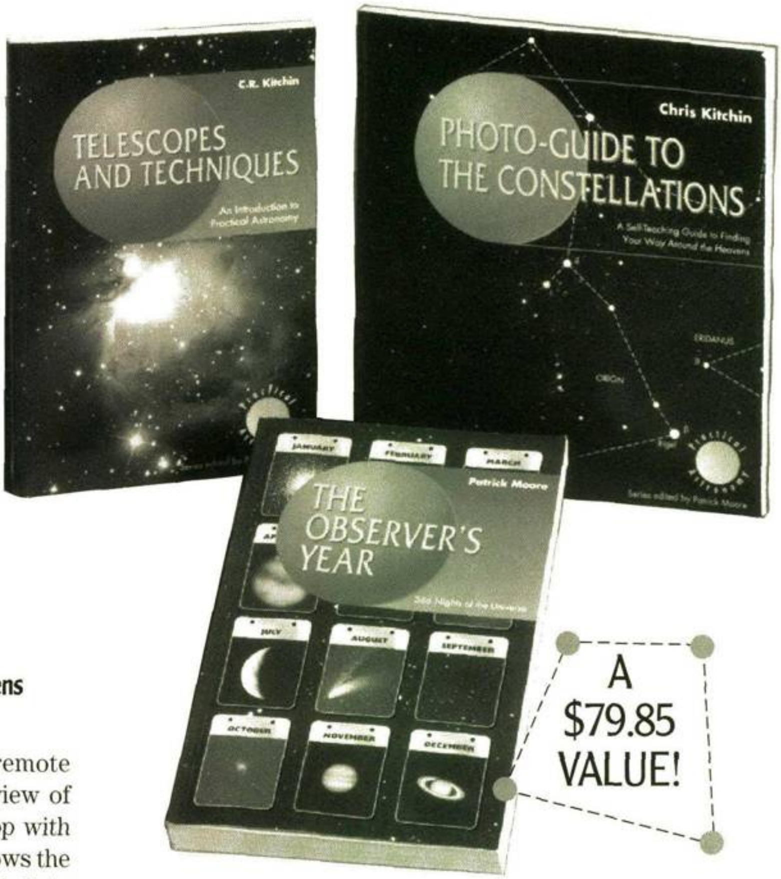
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I wanted a clean version where, like the Hubble Space Telescope, you would assemble the entire thing on the ground, test it, and once it is up there you pop it out, and it's running. — J. Roger Angel, Tucson, Arizona

Apt Astronews

Your October Astronews story "Blasting Asteroids" is relevant to society as a whole.

Near-Earth objects are recognized by scientists as a threat and, thanks to film maker Stephen Spielberg and others, the public is coming to the same opinion.

The extinction of humans, if we remain earthbound, is beyond dispute. The work of Erik Asphaug at the University of California at Santa Cruz, as described in the story, makes it all the clearer that we must build an extraterrestrial civilization before the next big comet or asteroid impact.

Since we do not know when such an event will occur, and because building a permanent sustainable presence in space will take a long time, there is no excuse for holding back. — *Michael Martin-Smith, President of Space Age Associates, Jesmond, England*

Naval Observatory Oversight

No mention was made in "Space in the Desert" in the November issue of the United States Naval Observatory's Flagstaff Station (USNOFS). Its staff accommodates "walk-ins" and school groups by appointment. Indeed, we believe, the USNOFS plays a big part in the lure of the area. — *Geoff Chester, Washington, D.C.*

Correction

The bird pictured on page 91 of the October issue was misidentified in the caption. It is a tricolored heron, not a great blue heron. We apologize.

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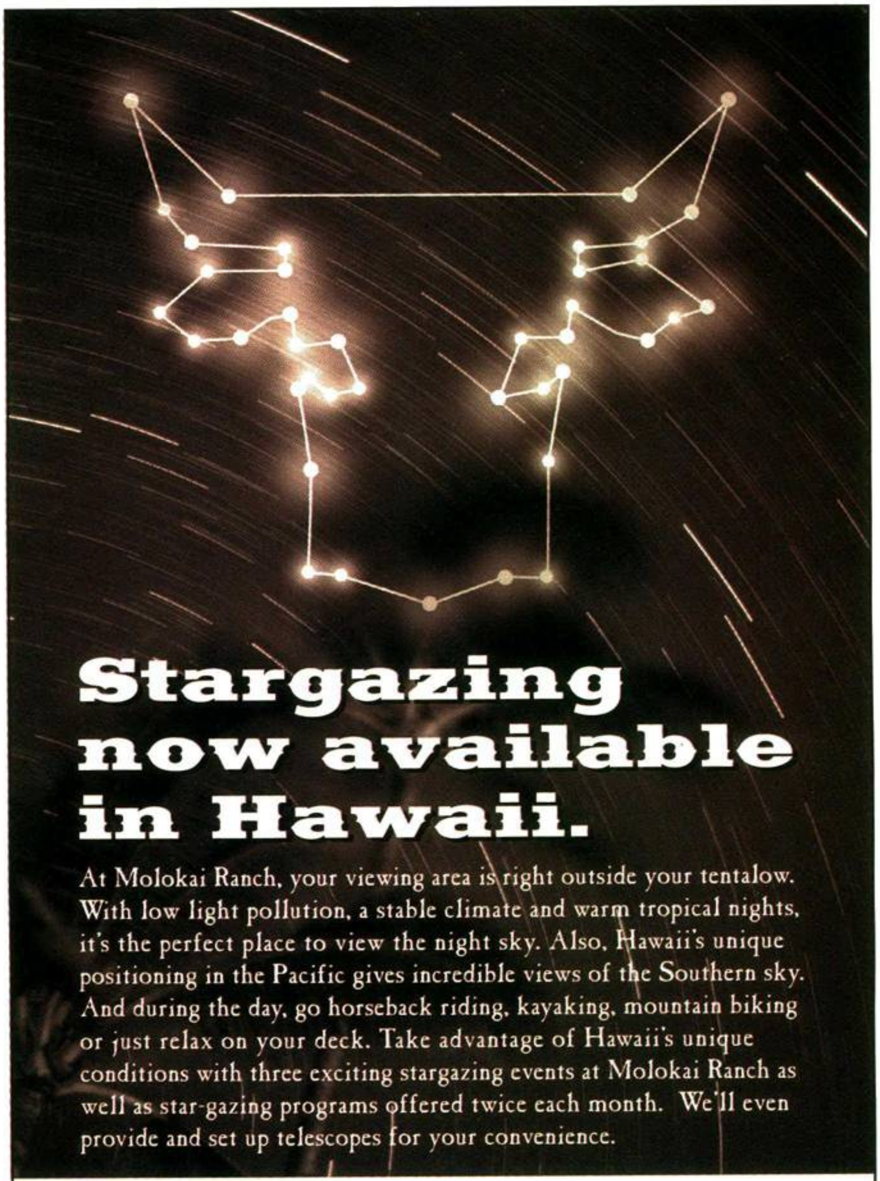

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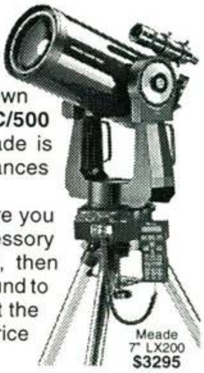

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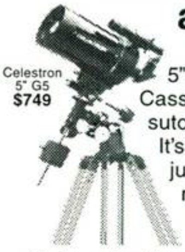

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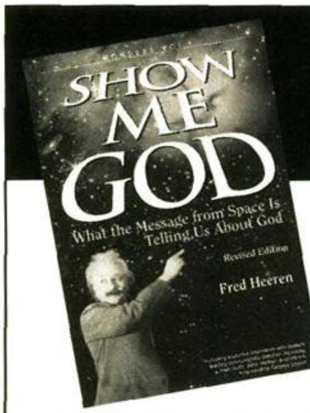

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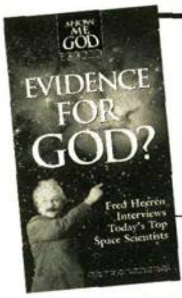

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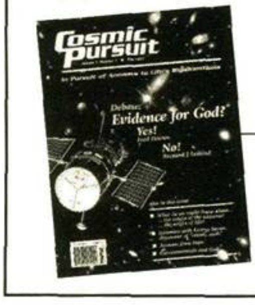

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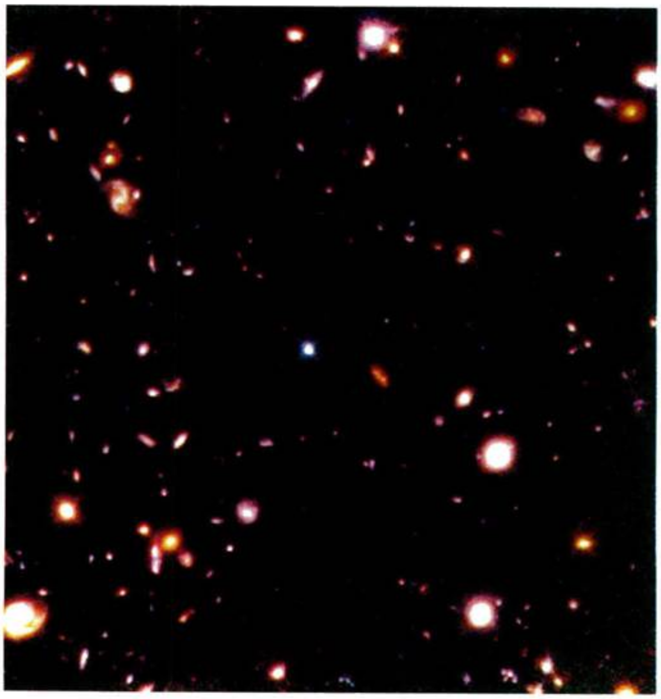
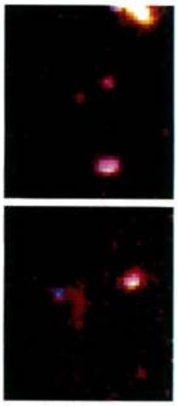
HUBBLE SPACE TELESCOPE

Deep Field, Part Deux

Hubble Goes the Distance





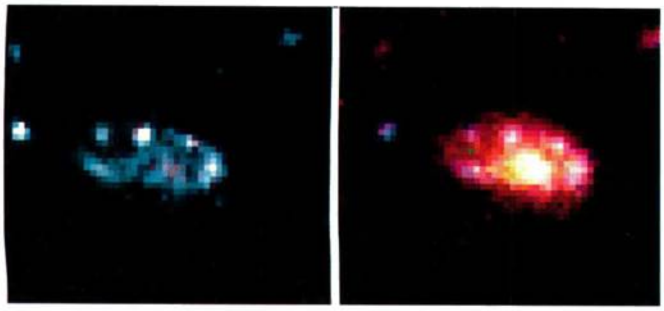
The NICMOS Deep Field (left), taken in infrared light, gives humanity its deepest look into space and time. Some of the red blips (above) appear to be galaxies whose light has been traveling toward Earth for more than 12 billion years. Rodger Thompson (University of Arizona) and NASA

▶ In January 1996 the Hubble Space Telescope made a big splash when astronomers released the Hubble Deep Field, an image collected over 10 days showing a tiny patch of sky near the Big Dipper. The image, taken mostly in visible light by the telescope's WFPC2 camera, was the deepest ever made — revealing galaxies to magnitude 30 (the brightness of a lit cigar on the moon as seen from Earth) that appeared as little more than faint red blips and fuzzy blue blobs. The picture gave astronomers a snapshot of galaxies as they existed when the universe was only 10 percent of its current age.

Hubble has just gone even deeper into the universe. A new image of a small portion of the original Deep Field was taken by NICMOS, the telescope's infrared camera. Even though the NICMOS image took only 72 hours of exposure time, it could go deeper than WFPC2 because the expansion of the universe stretches, or "redshifts," visible light into the infrared part of the spectrum.

"The NICMOS Deep Field takes us back to a time when the universe was only 5 percent of its present age, about 700 million years after the Big Bang," says University of Arizona astronomer Rodger Thompson, principal investigator of NICMOS.

In just that small region, the NICMOS Deep Field reveals more than 100 galaxies that didn't appear in the original image. In addition, the NICMOS picture shows that some of the small blips seen in the original Deep Field were just parts of larger galaxies. Intriguingly, one of the galaxies appears to be a mature spiral galaxy seen edge-on. "These could be galaxies that have formed a lot of stars and are relatively well organized," says Alan Dressler of the Carnegie Observatories, an expert on galaxy evolution.



A galaxy in the original Hubble Deep Field (left), taken in visible light, appears lumpy due to bright knots of starbirth. But a NICMOS Deep Field frame of the same galaxy (right) shows that the galaxy has an underlying population of older stars, giving it a disk-like appearance.

Rodger Thompson (Univ. of Arizona) and NASA

Thompson and Dressler both stress that much work needs to be done to know exactly how far away these galaxies really are. To confirm the distances to these galaxies, astronomers must take their spectra, which reveal how much the galaxies' light has been redshifted by the universe's expansion. Many of the galaxies are so faint, however, that only the Next Generation Space Telescope (scheduled to be launched around 2007) will be able to take their spectra.

Thompson says that by studying the NICMOS Deep Field, astronomers will piece together the story of how the universe evolved from a sea of particles following the Big Bang to the intricate system of stars and galaxies that we see today. — Robert Naeye

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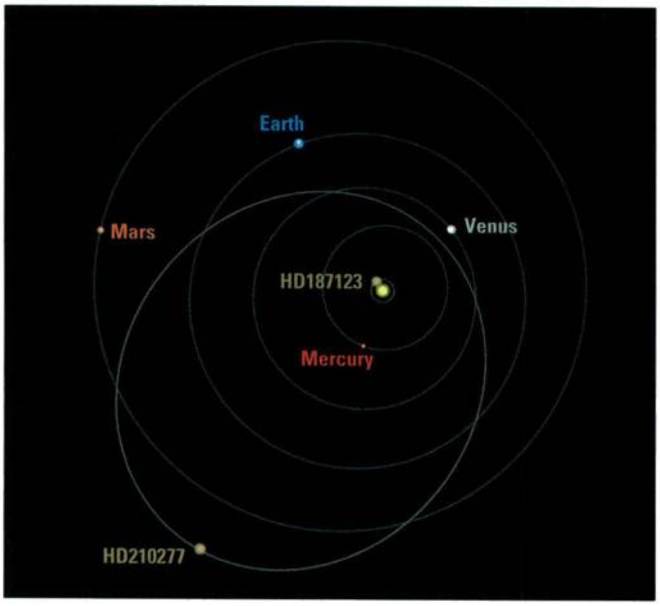


The two newly discovered extrasolar planets have very different orbits. The planet orbiting HD 210277 has the most Earth-like orbit of any planet discovered to date.

Astronomy: Elisabeth Rowan

EXTRASOLAR PLANETS

Chalk Up Two More Planets

▶ Planet hunters Geoff Marcy and Paul Butler have just bagged two more extrasolar planets, meaning astronomers now know of a dozen planets orbiting other sunlike stars.

One of the planets is the fifth known member of a class of planets called "hot Jupiters." This world orbits the star HD 187123, a virtual solar twin about 150 light-years away in Cygnus. The planet has a mass of at least half a Jupiter, yet it orbits its star at a distance of only 4 million miles, a mere one-ninth the distance at which Mercury orbits the sun. The planet hugs HD 187123 so closely that it whips around the star once every 3.1 days, the shortest orbital period of any planet discovered to date.

The other planet orbits HD 210277, a slightly larger version of the sun 68 light-years away in Aquarius. This planet weighs in with a mass of at least 1.4 Jupiters. The planet has the most Earth-like orbit found so far, with an average distance from its host star only 15 percent larger than Earth's distance from the sun and an orbital period of 437 days. But the orbit is highly elliptical — meaning the planet would be subjected to extreme temperature variations.

(see "Planets," p. 30)

TELESCOPE TECHNOLOGY

Nulling a Star

▶ Now that astronomers are detecting the gravitational influence of extrasolar planets on their host stars, the next step is to image the planets themselves. Such a task is easier said than done, because the blazing light of a star drowns out the feeble light of any attendant planets. Imaging an extrasolar planet is like trying to see a candle next to a searchlight from 100 miles away.

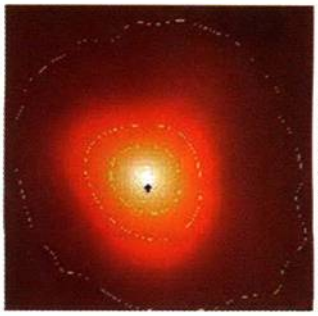
In 1978, Stanford University physicist Ronald Bracewell thought of a way around this problem. By using secondary optics, two telescope mirrors can be configured to cancel out star light. The key is to make sure that the star light bouncing off one mirror travels a slightly longer path than light bouncing off the other mirror. If done just right, the wave crests from one mirror will arrive at a detector at exactly the same moment as the troughs from the other mirror. Because the light waves arrive out of phase, the star's light is canceled out, or "nulled." But a planet's light, which will be offset from the star, will travel a slightly different path through the optics, meaning its light will remain intact.

In a September 17, 1998, *Nature* paper, a University of Arizona team led by Philip Hinz and Roger Angel demonstrated that this setup — called a nulling interferometer — actually works. Using two of the Multiple Mirror Telescope's six 1.8-meter mirrors, the team imaged three bright stars in infrared light: Betelgeuse, Aldebaran, and R Leonis. In each case, they nulled 95 percent of the star's light. The Betelgeuse image revealed a surrounding gas cloud that astronomers had known about but had never directly imaged. "We showed that we can actually cancel out the star light and see something right next to the star," says Hinz. "It's a technique that has been worked out on paper for some time now, but until you actually do it, it's something that remains unknown."

This is just the first of many steps. Future nulling interferometers will have to cancel 99.99 percent of a star's light, and adaptive optics and larger mirrors are musts. Hinz predicts that the twin 8.4-meter mirrors of the Large Binocular Telescope, currently under construction on Mt. Graham in Arizona, will be able to image extrasolar Jupiter-sized planets when operative around 2003.

Bracewell is looking even further ahead. "These results augur well for the planning of a future launch of a more powerful nulling interferometer toward the orbit of Jupiter," he says. Such an instrument could image Earth-sized planets orbiting other stars.

Astronomers canceled out 95 percent of Betelgeuse's light, enabling them to see a faint gas cloud that is slightly off center from the star.



Phil Hinz (University of Arizona), et al.

M51 Whirlpool Galaxy. The first galaxy found to have spiral structure is about 35 million light years distant and about 10 arc minutes in apparent diameter. This five-minute ST-5C exposure was taken in moderate light pollution with a Celestron C8 reduced to f/4 using the ST-5C focal reducer. Courtesy Alan Holmes and Michael Barber / SBIG.

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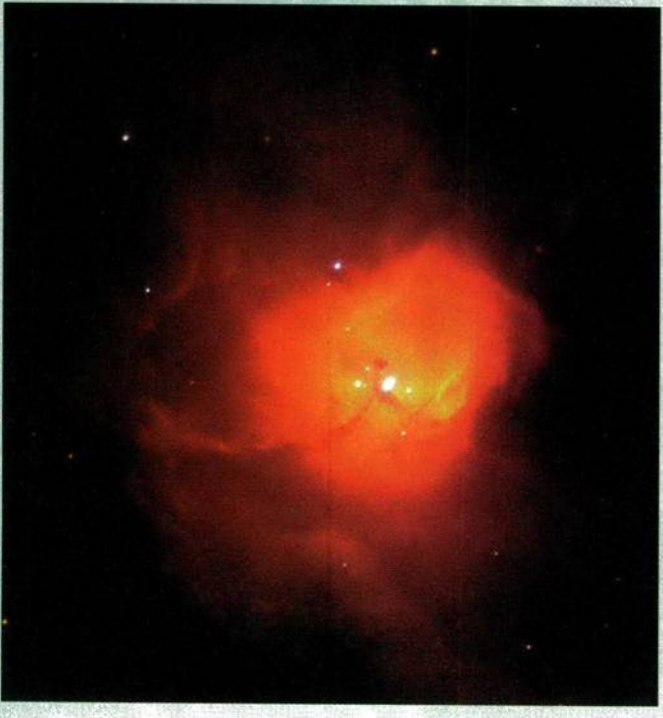

Mohammad Heydari-Malayeri (Paris Observatory) and NASA/ESA

CELESTIAL FIREWORKS. Astronomers observing distant galaxies notice that some of them are undergoing furious bouts of massive star formation. With this Hubble Space Telescope natural color image, astronomers get a bird's-eye view of a scaled-down version of this phenomenon. Hubble allows us to peer deep into the heart of N81, an embryonic cloud of glowing gas 200,000 light-years away in the Small Magellanic Cloud (a satellite galaxy of the Milky Way). Astronomers used to call N81 "The Blob" because ground-based telescopes couldn't resolve its features. But with Hubble's sharp vision, astronomers have counted 50 massive stars, each shining with the energy of about 300,000 suns, crammed into a region only 10 light-years across. The two bright stars in the center are radiating torrents of ultraviolet light, providing the power that illuminates the entire nebula from within. The dark lanes consist of residual dust.

(Planets)

Both planets were discovered indirectly, by the wobble their gravitational force exerts on their parent star. Marcy and Butler found them with the 10-meter Keck I Telescope in Hawaii, using a high-precision spectrometer built by Steve Vogt of the University of California, Santa Cruz.

British amateur astronomer Kevin Apps, now a sophomore physics major at the University of Sussex, helped Marcy and Butler discover the HD 187123 planet. Apps used Hipparcos data to determine that 30 of the 430 stars on Marcy and Butler's target list were giants, making them poor candidates for the planet search. Apps supplied Marcy and Butler with a list of 30 alternates, and HD 187123 was on the list. "I don't think I can put into words how I feel about Geoff and Paul finding a planet around one of my suggested targets," says Apps.

"Finding planets continues to be great fun," adds Butler. "Now that the initial media rush of the last few years is subsiding, we can concentrate on the science — improving our precision and answering fundamental questions about planet formation."

MARTIAN METEORITES

Wrangling Over a Rock

▶ The potato-sized martian meteorite ALH84001 has been the center of a raging scientific controversy since 1996, when a team of NASA and university scientists claimed to have found evidence of ancient martian microbes in the rock. Both skeptics and believers recently offered new results to bolster their respective views.

University of Hawaii geophysicist Ed Scott and colleagues argue that the meteorite's organic material — gold-hued carbonate crystals — resulted from high-temperature impacts rather than low-temperature biological activity. An analysis of the shapes and compositions of the carbonates, the researchers say, shows that the crystals must have been formed when an impact forced melted carbonates into cracks in the rock. "The evidence against life in ALH84001 has been steadily accumulating during the past year," says Scott.

But the NASA team has new data supporting martian life in ALH84001. "The majority of the scientific community now believes the carbonates formed at low temperatures," says team member Everett Gibson of NASA's Johnson Space Center. Gibson and his colleagues have added evidence of biofilms, coverings generated by bacteria in hostile

(see "Rock," p. 32)

"Lucky 13" is the newest little piece of Mars found on Earth.

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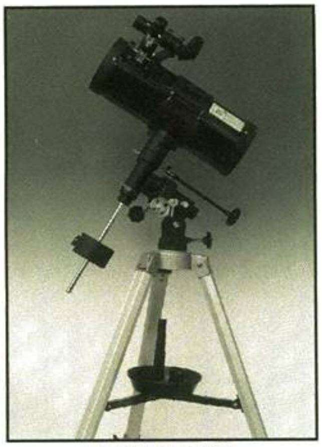

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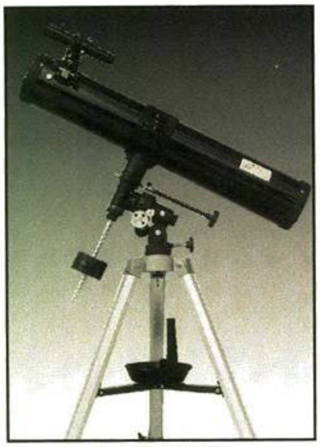

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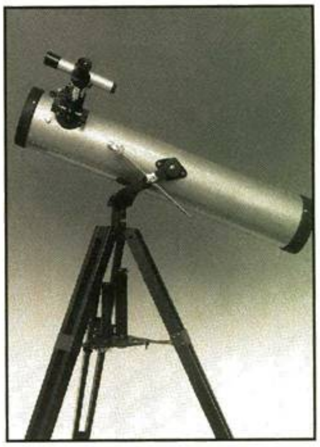

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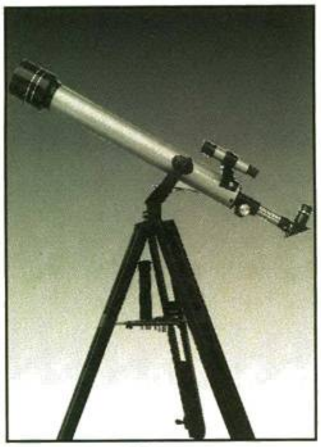

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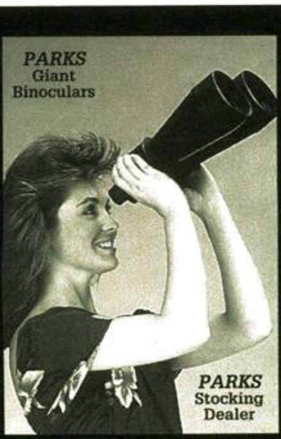
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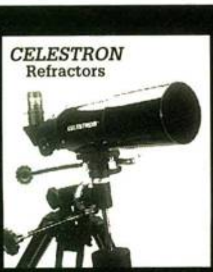
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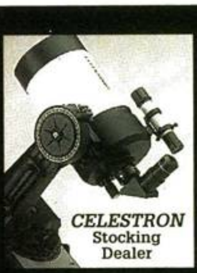
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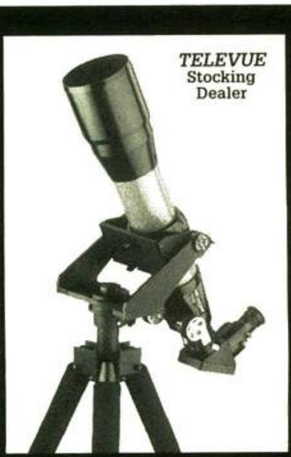
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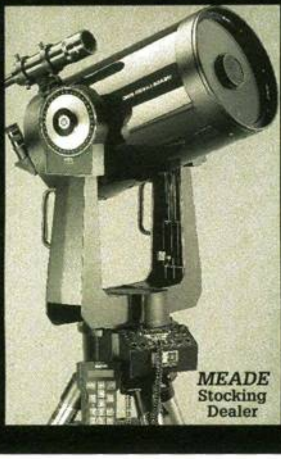
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(Rock)
environments, to the list of pro-life arguments.

Despite two years of intensive research, the question of life in ALH84001 remains open. In the meantime, another martian meteorite has been found. Discovered in the Sahara Desert, the 4.8-pound (2.2 kg) rock is the 13th confirmed meteorite from Mars. Studies at the Max-Planck-Institute for Chemistry in Mainz, Germany, indicate the rock was blasted from Mars about one million years ago and arrived in North Africa thousands of years ago. — Michael Carroll

MAGNETARS

Earth Pounded by Distant Stellar Burst

▶ On August 27, a supercharged blast of high-energy radiation washed over our planet. The blast originated when a massive "starquake" wracked a highly magnetized neutron star, or magnetar, located 20,000 light-years away.

When the wave of x rays and gamma rays hit Earth's nightside, they tore electrons off atoms and molecules in the upper atmosphere, ionizing them in the same way as the sun's ultraviolet radiation does during daylight. Normally this ionized layer, called the ionosphere, lies some 53 miles (85 km) above Earth's surface at night, but the radiation deluge caused the inner edge of the ionosphere to dip down to noontime levels, about 37 miles (60 km) high.

"It was as if night turned into day in the ionosphere," said Umran Inan of Stanford University, who heads the research group that observed the disturbance. For those who might have been listening that night to a distant AM radio station (those signals can travel thousands of miles by bouncing off the quiet nighttime ionosphere), the 5-minute-long pulse would have caused the station to briefly fade out.

The blast had no effect on Earth's surface, and even cosmonauts on the space station Mir received less radiation than from a typical dental x ray. But a number of spacecraft proved less than immune to the radiation. The burst temporarily shut down the Rossi X-ray Timing Explorer and the Near-Earth Asteroid Rendezvous spacecraft, among others.

The culprit appeared to be an exotic neutron star in Aquila designated SGR 1900+14, one of just a handful of known magnetars (see "Most Powerful Magnetic Field Discovered," AstroNews, September 1998). The magnetar's magnetic field, which is 800 trillion times stronger than Earth's and some 100 times stronger than any other known in the universe, can cause the rigid crust to ripple and crack. Such a starquake released the torrent of high-energy radiation that inundated Earth on August 27.

"A magnet this strong could pull the keys out of your pocket from halfway to the moon," says Robert Duncan of the University of Texas, who along with Christopher Thompson of the University of North Carolina, predicted the existence of magnetars in 1992. — Richard Talcott

Luke Dodd

The Large Magellanic Cloud is being torn asunder and consumed by the much larger Milky Way.

THE MILKY WAY

Our Galaxy's Hearty Appetite

▶ The Milky Way has a solid reputation as a cannibal. But a long filament of hydrogen gas being yanked out the front of nearby galaxies suggests it's not just nibbling at its neighbors, it's tearing them apart.

Astronomers have debated the nature of our galaxy's dining habits since the detection 35 years ago of a long trail of neutral hydrogen gas stretched out behind the Large and Small Magellanic clouds, small satellite galaxies of the Milky Way. A second stream of hydrogen out in front of the galaxies, recently discovered with the 65-meter Parkes radio telescope in Australia, could end the long debate.

"In one picture, our galaxy is big and mean, cannibalizing and shredding our closest neighbors. In the other, our galaxy is a kinder beast, gently tugging the gas out," says Brad Gibson of Mount Stromlo Observatory in Australia, part of the international team of astronomers who described the new stream at an August conference in Canberra.

In the "kind" model, called ram pressure stripping, a single stream of gas is dragged out behind the Magellanic Clouds as they move through the Milky Way's hot halo. This theory could explain a stream trailing the Magellanic Clouds, but not one out in front, says Mary Putman, Gibson's doctoral student who imaged the leading stream. "It would be like if you were blow-drying your hair and some of your hair came toward the blow-dryer."

The "mean" model, called tidal forcing, requires a second stream of gas. Much the way the moon's gravity raises ocean tides on Earth, the Milky Way's gravity tugs the closer side of the Magellanic Clouds a little harder than the far side, stretching relatively circular balls of gas and stars into a cigar shape.

(see "Appetite," p. 34)

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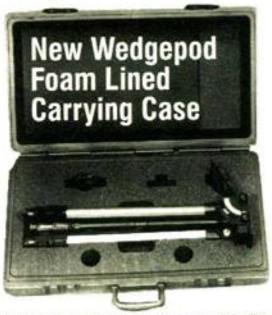

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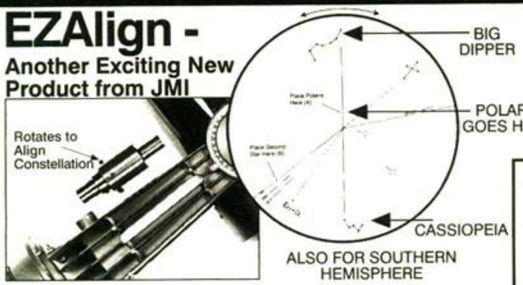

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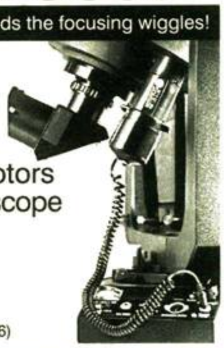

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(Appetite)
Gas escapes most readily from the two tips of the cigar, where the surface gravity is less.

Finding the second, leading stream "sounds the death knell for the ram pressure model," Gibson says. It also means the Milky Way may owe some of its grandeur to neighbors it devoured long ago, pulling their stars and gas into its own revolving disk.

— Sarah Simpson

RADIO ASTRONOMY

Zooming in on Quasars

▶ Using a network of radio telescopes, including one in space, an international group of astronomers has produced unprecedented images of quasars, immensely energetic objects thought to be powered by supermassive black holes.

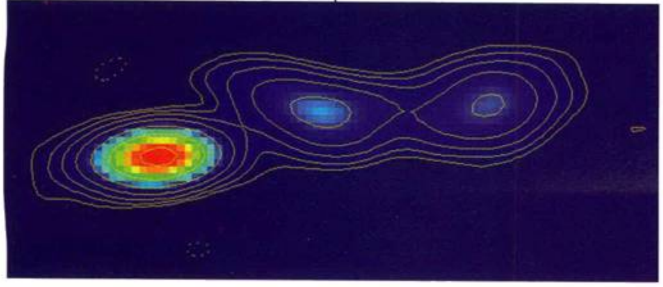
The effort, dubbed the Very Long Baseline Interferometry Space Observatory Programme (VSOP), links 40 radio telescopes from Japan, the United States, Canada, Australia, the Netherlands, Russia, and Sweden. But it also includes an orbiting Japanese 8-meter radio telescope, called the Highly Advanced Laboratory for Communications and Astronomy (HALCA).

Altogether, these scopes combine to achieve a resolution equal to a single radio telescope several times larger than the entire Earth. In fact, this array would have the resolution to read the words in this article from a distance of several thousand miles.

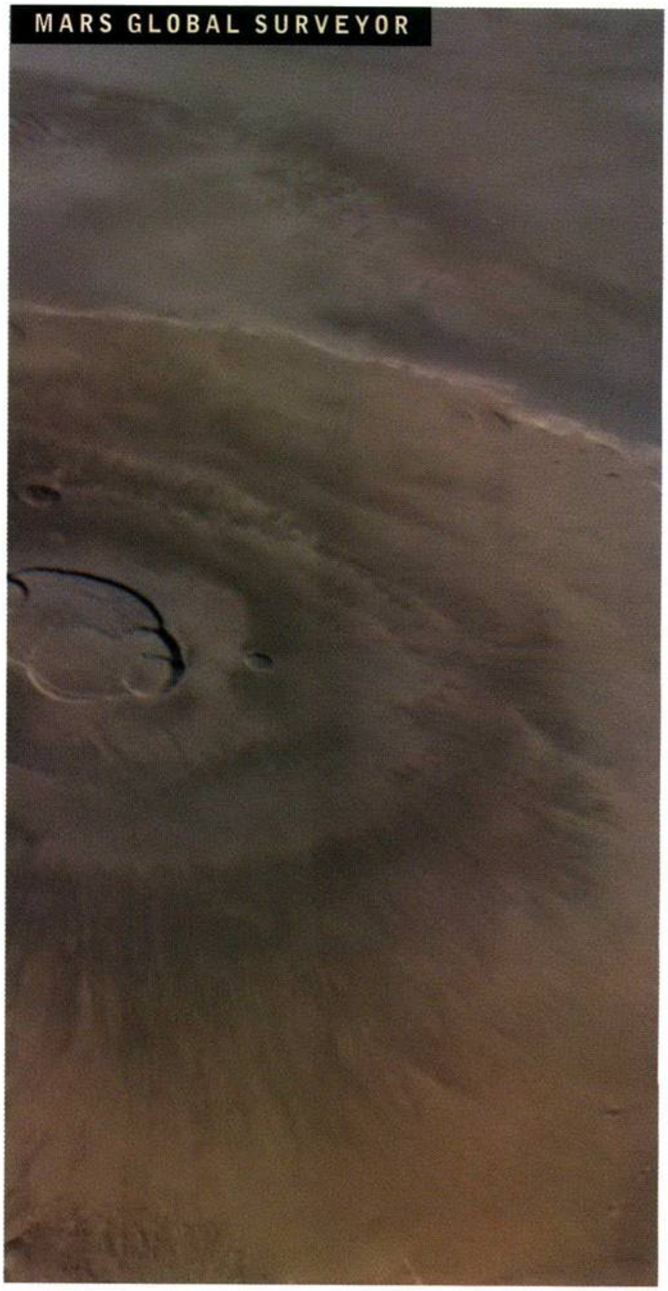
The team recently used the array to zoom in on the hearts of three quasars. Powerful jets of subatomic particles are shooting out from each of these quasars. These jets span 1 million light-years, and the jet particles are ripping through space at nearly the speed of light. The resulting VSOP images of the innermost regions of these jets, published in the September 18 *Science*, showed that the jets are produced within 0.3 light-year of the central black holes. The jets also have wiggly structures, perhaps due to magnetic fields in the vicinity of the black holes or to motion of the black hole systems.

"No other technique allows us to look so closely at the vicinity of a black hole," says team member David Meier of NASA's Jet Propulsion Laboratory.

— Tracy Staedter



In this radio image of quasar 0014+813, the red region represents the galactic core, the area where astronomers believe a monster black hole resides. The blue streak indicates a jet of high-speed particles that points toward us. VSOP collaboration



THE MOUNTAIN KING. This spectacular oblique shot of Olympus Mons comes courtesy of Mars Global Surveyor, which flew 560 miles (900 km) over the giant volcano on April 25, 1998. Olympus Mons rises 85,000 feet (26 km) above the surrounding terrain, giving it the distinction of being the highest mountain in the solar system (see "Planetary Face-Off," page 58). Despite Olympus Mons's tremendous height, its average slope is a gentle 2° to 5°. If you were randomly plopped down on its flanks (wearing a space suit, of course), you might have a difficult time telling which way was uphill. While the colors in this picture are not greatly exaggerated, the colors would look paler and the contrast more subdued if you were looking down on Olympus Mons from orbit. The image was publicly released in October 1998 at the American Astronomical Society's Division for Planetary Sciences conference in Madison, Wisconsin. Malin Space Science Systems/NASA

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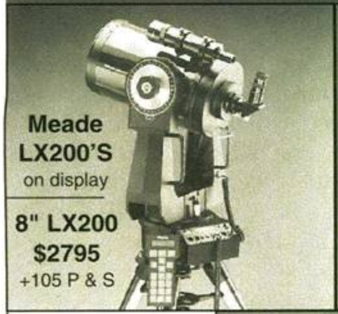

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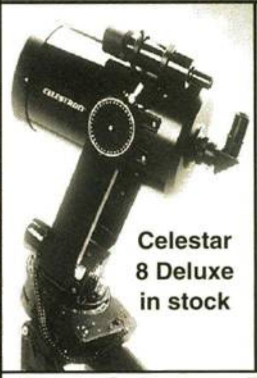

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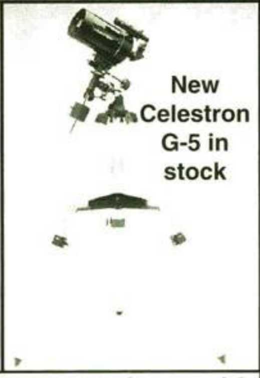

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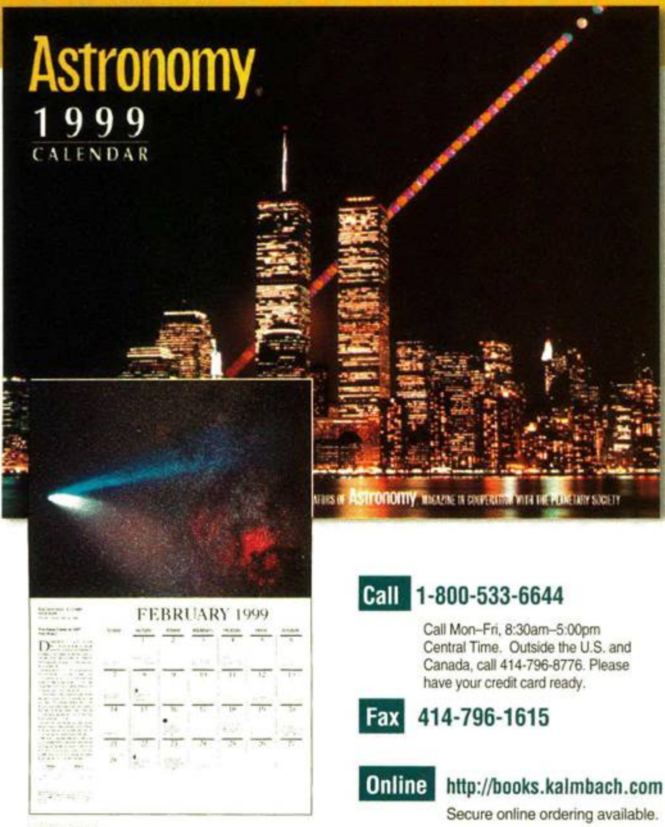

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LUNAR PROSPECTOR

Craft Hints at Moon Core

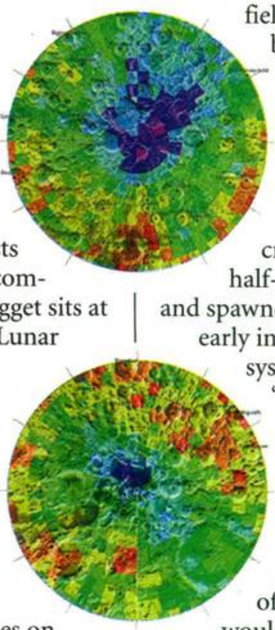
▶ The desk-sized Lunar Prospector spacecraft, zipping 60 miles (100 km) above the moon's dusty seas, has yielded new insights about the hidden heart of Earth's companion. Planetary scientists suspected that a compact iron-rich nugget sits at the moon's core. Lunar Prospector's detailed gravity and magnetic studies, published in the September 4 *Science*, offer the strongest evidence yet.

Radio telescopes on Earth tracked the explorer's orbit to chart the peaks and valleys of the moon's gravitational field. The resulting gravity map revealed the distribution of mass within the moon five times more accurately than before, says Alex Konopliv of NASA's Jet Propulsion Laboratory. It appears the moon has a metallic core between 275 and 560 miles (440 to 900 km) across. Such a core would hold just 1 to 4 percent of the moon's mass.

A magnetic probe aboard Lunar Prospector supported that claim by finding strong patches of magnetism in the moon's crust. "We suspect those patches are remnant signatures of a strong magnetic field on the moon billions of years ago," says Robert Lin of the University of California at Berkeley. The lunar field, which may have been as intense as Earth's field is today, probably arose from a swirling core of hot iron.

A small core meshes with a theory that a Mars-sized body crashed into the half-formed Earth and spawned the moon early in the solar system's history (see "Deconstructing the Moon," September 1998). Computer simulations suggest that the shattered center of the impactor would condense into a new lunar core after the collision. "The giant-impact theory has no problem explaining a core of that size," says Robin Canup of the Southwest Research Institute in Boulder, Colorado.

Lunar Prospector also looked more closely at hydrogen levels in the moon's soil near its poles. Mission scientists believe the hydrogen is locked within ice deposits in permanently shaded craters, although other explanations are possible. If the ice scenario holds up, says William Feldman of Los Alamos National Laboratory, the latest data point to about 3 billion tons of water — 10 times higher than the team first reported last March. — ROBERT IRION



Purple and magenta areas in the north (top) and south polar regions (bottom) have excess hydrogen levels, probably due to water ice. Los Alamos National Laboratory

Royal Greenwich Observatory, R.I.P.

One of the most venerable institutions in astronomy, the Royal Greenwich Observatory (RGO) in Cambridge, England, officially closed its doors this past October after 300 years of service. RGO lost out to the Royal Observatory in Edinburgh, Scotland, in an effort to become Britain's chief headquarters for operating telescopes overseas, and officials decided to close RGO as a cost-savings measure. RGO's name may live on, however. British scientists and government officials are considering transferring the name to its original site in Greenwich, where a museum currently resides.

Arecibo Survives Hurricane Georges

The world's largest radio telescope, the 1,000-foot-diameter dish at the Arecibo Observatory in Puerto Rico, took a near-direct hit from Hurricane Georges on September 21. Packing winds of 120 miles per hour, the hurricane ravaged much of Puerto Rico, leaving more than 99 percent of the island without power and three-quarters without water. The observatory, however, escaped relatively unscathed. A few of the telescope's reflecting panels suffered minor damage from flying debris and part of the support system was affected, but full operations were expected to be restored within a couple of months. Amazingly, the observatory operated on an emergency generator throughout the storm, and a group of atmospheric scientists even made radar observations during the hurricane.

Hurricane Georges damaged homes near Arecibo, but the observatory came away nearly unscathed. Ernesto Ruiz

Fireball Lights Up Greenland's Sky

One of the brightest fireballs ever recorded briefly turned Greenland's night into day on December 9, 1997. Several eyewitnesses reported that the fireball was nearly as bright as the sun. Initial calculations suggested that the space rock was traveling so fast that it originated from outside the solar system. But astronomer Holger Pedersen of Copenhagen University in Denmark says that it now appears to have been a solar system rock 3 to 10 feet (1 to 3 meters) across. This past summer a team led by Lars Lindberg Christensen of the Tycho Brahe Planetarium in Copenhagen searched unsuccessfully for meteorite fragments on the Greenland ice sheet. But the team collected 200 dust samples, which are currently being analyzed at Copenhagen University.

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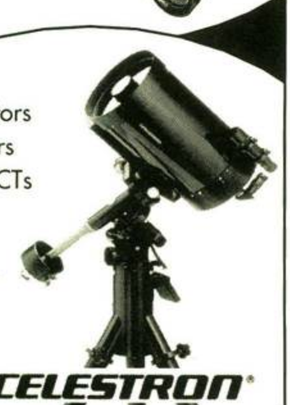

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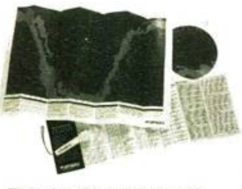

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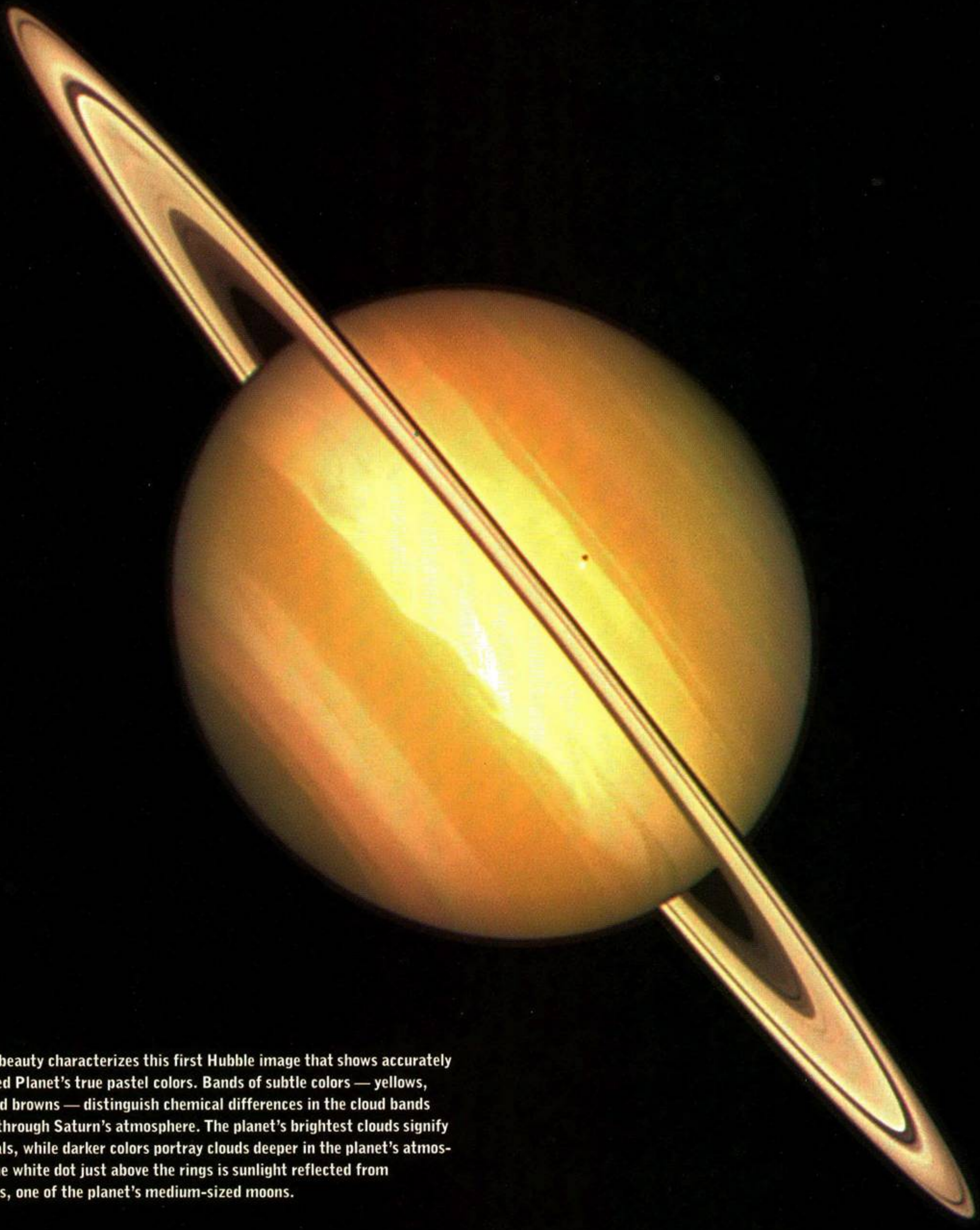
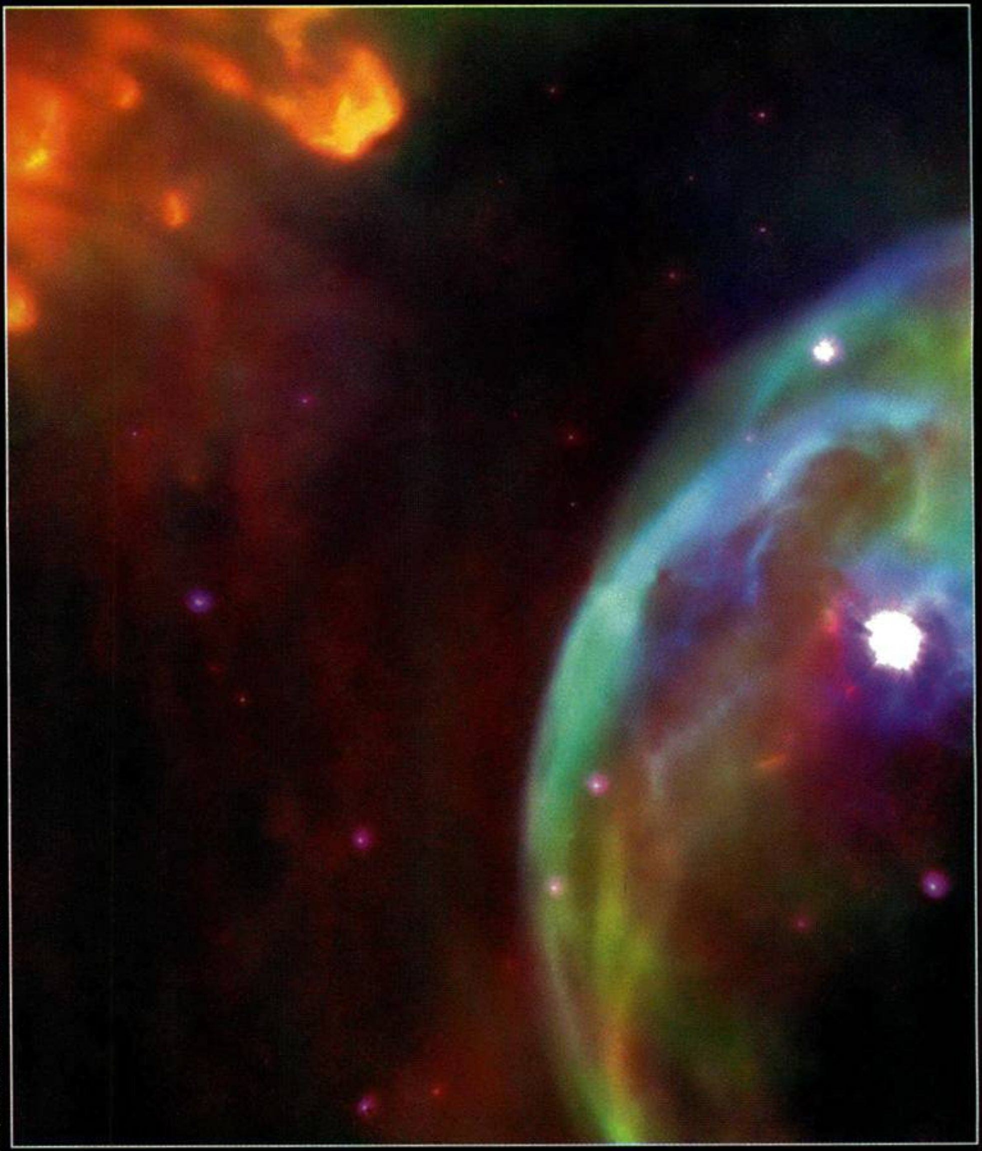
Hubble Looks Back

On a good orbit, the Hubble Space Telescope helps astronomers to look ahead by providing vast amounts of new data and imagery. But a new program initiated by scientists at the Space Telescope Science Institute in Baltimore promises to produce a vibrant color album filled with old images. The Hubble Heritage Program, introduced in late 1998, will dip back into the vast array of more than 130,000 images taken with Hubble but not released to the public.



Saturn's beauty characterizes this first Hubble image that shows accurately the Ringed Planet's true pastel colors. Bands of subtle colors — yellows, grays, and browns — distinguish chemical differences in the cloud bands rotating through Saturn's atmosphere. The planet's brightest clouds signify ice crystals, while darker colors portray clouds deeper in the planet's atmosphere. The white dot just above the rings is sunlight reflected from Enceladus, one of the planet's medium-sized moons.



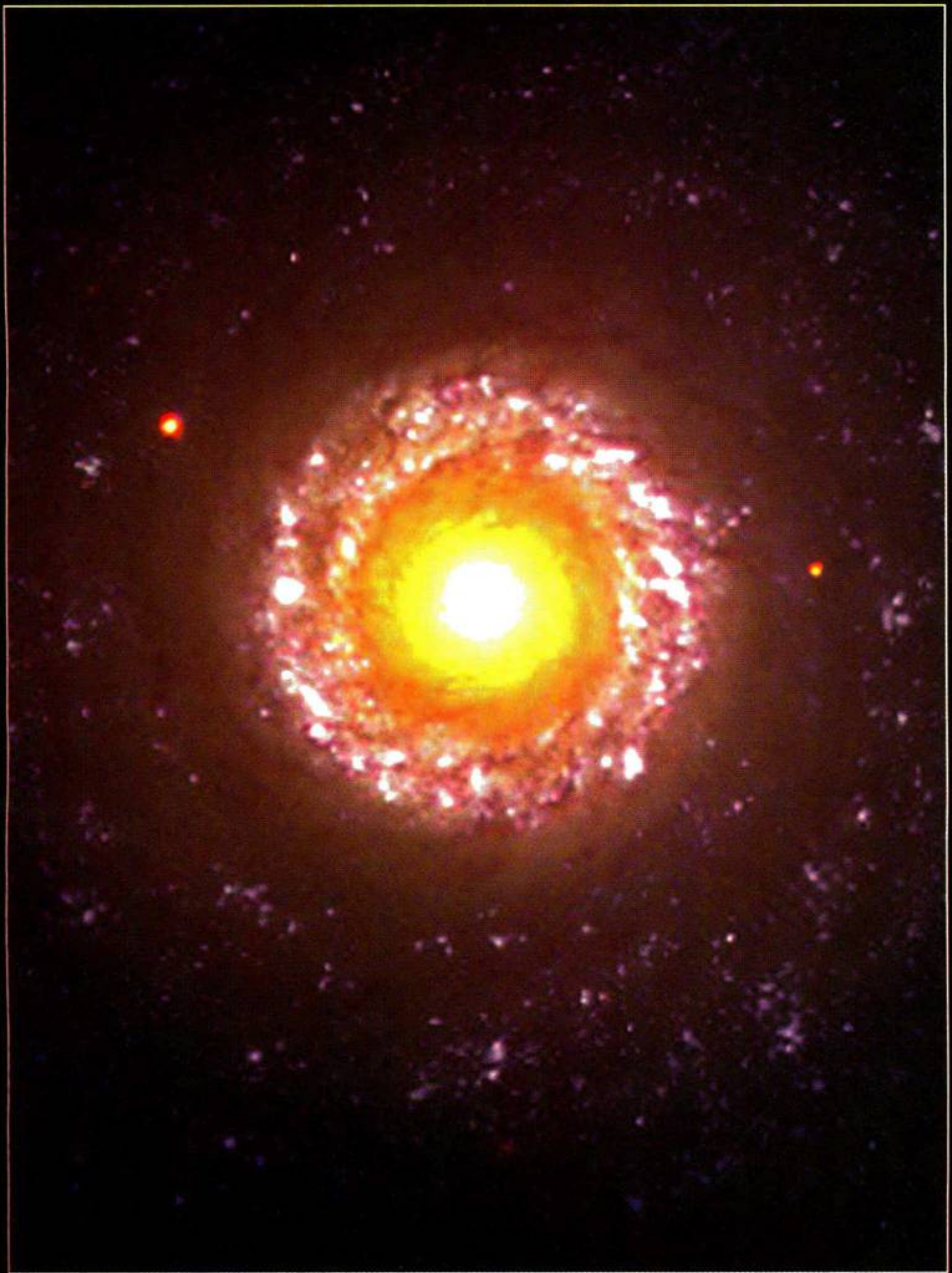
All photos unless otherwise noted: STScI

A cosmic bubble blown by the fierce winds of a hot B-type star (at right), the Bubble Nebula (NGC 7635) in Cassiopeia flares across Hubble's narrow field. The star's radiation pressure is sculpting the bubble shape as the highly energetic radiation from the star ionizes the gas and makes it glow brightly. The bubble spans 10 light-years, more than twice the distance from Earth to the nearest star other than the sun. The glowing gas at bottom right is being swept by the star's energy, creating the finger-like dark features. Above: The Bubble Nebula imaged from the ground.

Preston Scott Justis

"These images communicate, at a visceral level, the awe and excitement that we experience when exploring the universe with Hubble," says Heritage program scientist Keith Noll. "It is our chance to repay the public that supports us."

After this initial release of four images, the program will make available one new image from the old Hubble archive per month. The first group includes a natural color photo of Saturn, a spectacularly detailed image of a typical NGC galaxy with an active nucleus, a piece of the well-known Bubble Nebula, and a star-filled window into the galaxy's hub toward Sagittarius.

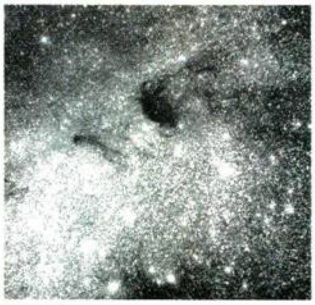


Hubble brings a vast new clarity to our picture of the face-on spiral galaxy NGC 7742 in Pegasus. This 12th-magnitude object is a so-called Seyfert, a peculiar type of spiral galaxy with an active, energetic nucleus. The galaxy's core, appearing yellow, probably hides a supermassive black hole. The lumpy, thick ring of stars and gas around the core, stretching 3,260 light-years from the center, pinpoints an area of active starbirth. The outer ring of gas clouds and star clusters marks the remains of an ancient stellar breeding ground. Above: NGC 7742 as recorded in the first Palomar Sky Survey.

Photo Courtesy : DDS

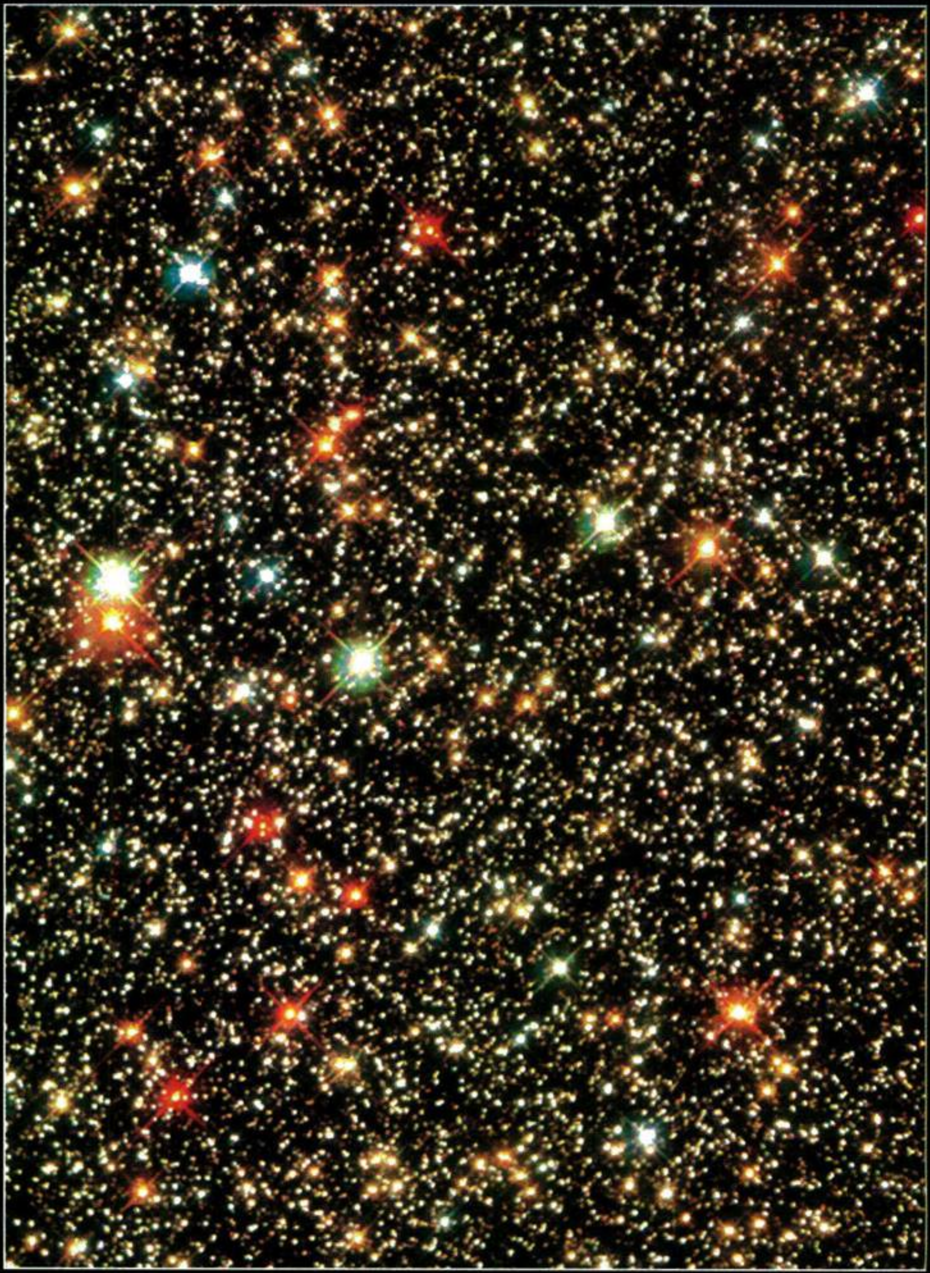
Hubble has imaged more than 10,000 objects, but only a few hundred of the images have been released. Part of the point of the Heritage program is to share images that are just purely pretty but without proven scientific value as yet.

The scientists want to provide Hubble views of old familiar objects you've seen in your telescope, so expect to see some pieces of Messier objects like you've never seen them before. One limitation stands out: Hubble's field of view is so small that only very small galaxies, clusters, and planetary nebulae can comfortably fit in; larger objects require a mosaic of several exposures.



A keyhole view of the heart of the Milky Way comprises this star-studded area of the Sagittarius Star Cloud (M24). Most of the area of sky toward the center of the Milky Way, a region inhabited by millions of stars, is obscured by intervening dust. For this view, Hubble peered through a relatively dust-free window to capture old stars residing in the galaxy's hub. By studying these aged stars, Hubble scientists will learn more about stellar evolution. Above: The Sagittarius Star Cloud in its entirety.

Michael Stecker



The task of selecting images from the Hubble archive is a daunting one. It involves more than just flipping through the four thousand gigabytes of data thus far created with the world's best known telescope.

These stunning images were created by the image processing specialists at the institute. Hubble's camera can only take images in black and white. To create the color versions seen here, the imaging specialists meticulously combined separate exposures made through different filters.

The result, which will visit us now each month with a fresh inhabitant of the universe, will provide a new view from old data. It will give us new insights into old friends, painting galaxies and stars with fresh faces. A

— *David J. Eicher*

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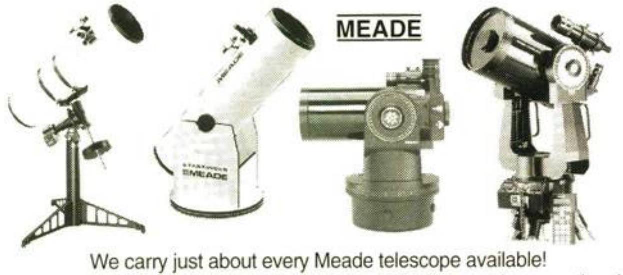

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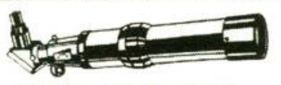

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PURSUING THE

MOST EXTREME STARS

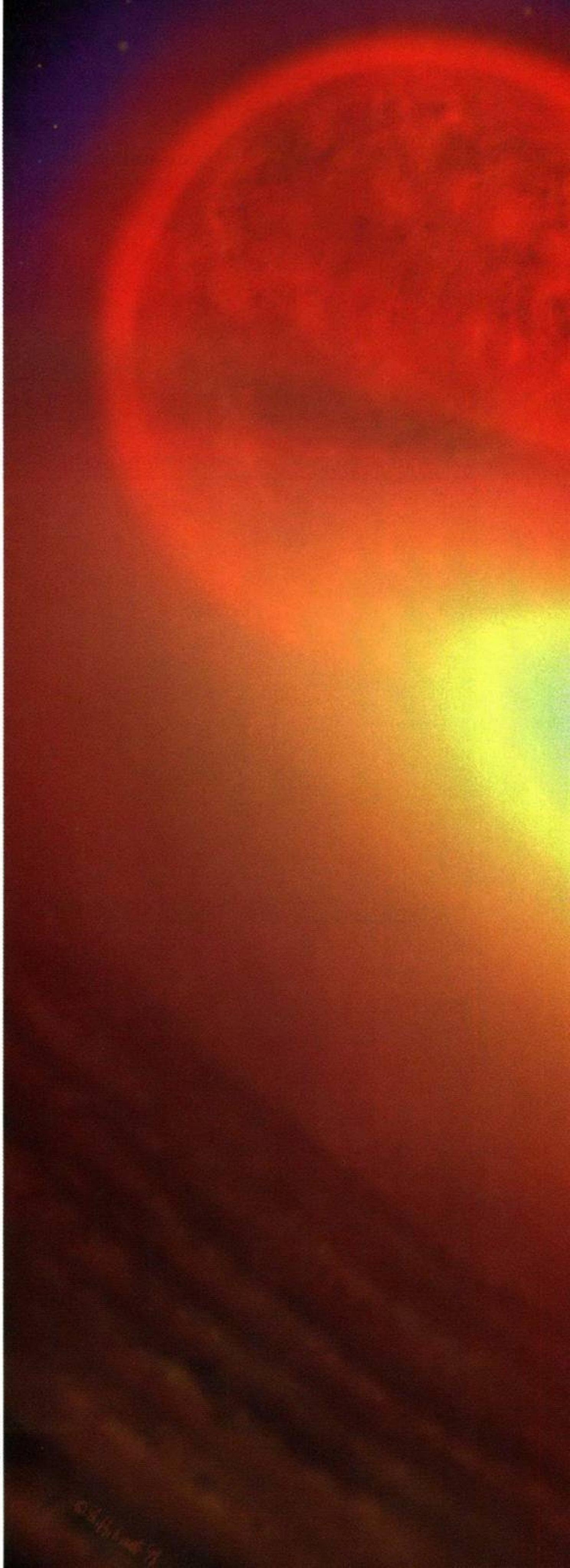
The galaxy's spinning neutron stars display some of astronomy's most astonishing behaviors.

by Robert Irion

Adjectives fly furiously when astronomers talk about the whirling dervishes called pulsars. Fastest spinning stars. Strongest magnetic fields. Greatest observable surface gravity. Quickest travelers in the galaxy. And the densest things in the universe save for black holes, which inhabit a bizarre realm all their own.

Pulsars are rotating neutron stars, the city-sized remnants of massive stars that die in supernova explosions. Spinning dozens of times per second or more, pulsars sweep the Milky Way with tight flares of radiation. It comes as no surprise that researchers must use all areas of known physics to explore these celestial eccentrics. "Pulsars display extremes that we will never duplicate in the lab," says physicist Roger Romani of Stanford University. "By studying them, we ultimately hope for a deeper understanding of the universe and the nature of matter itself."

In the 31 years since British astronomers found the first pulsar lurking as a mysterious "piece of scruff"



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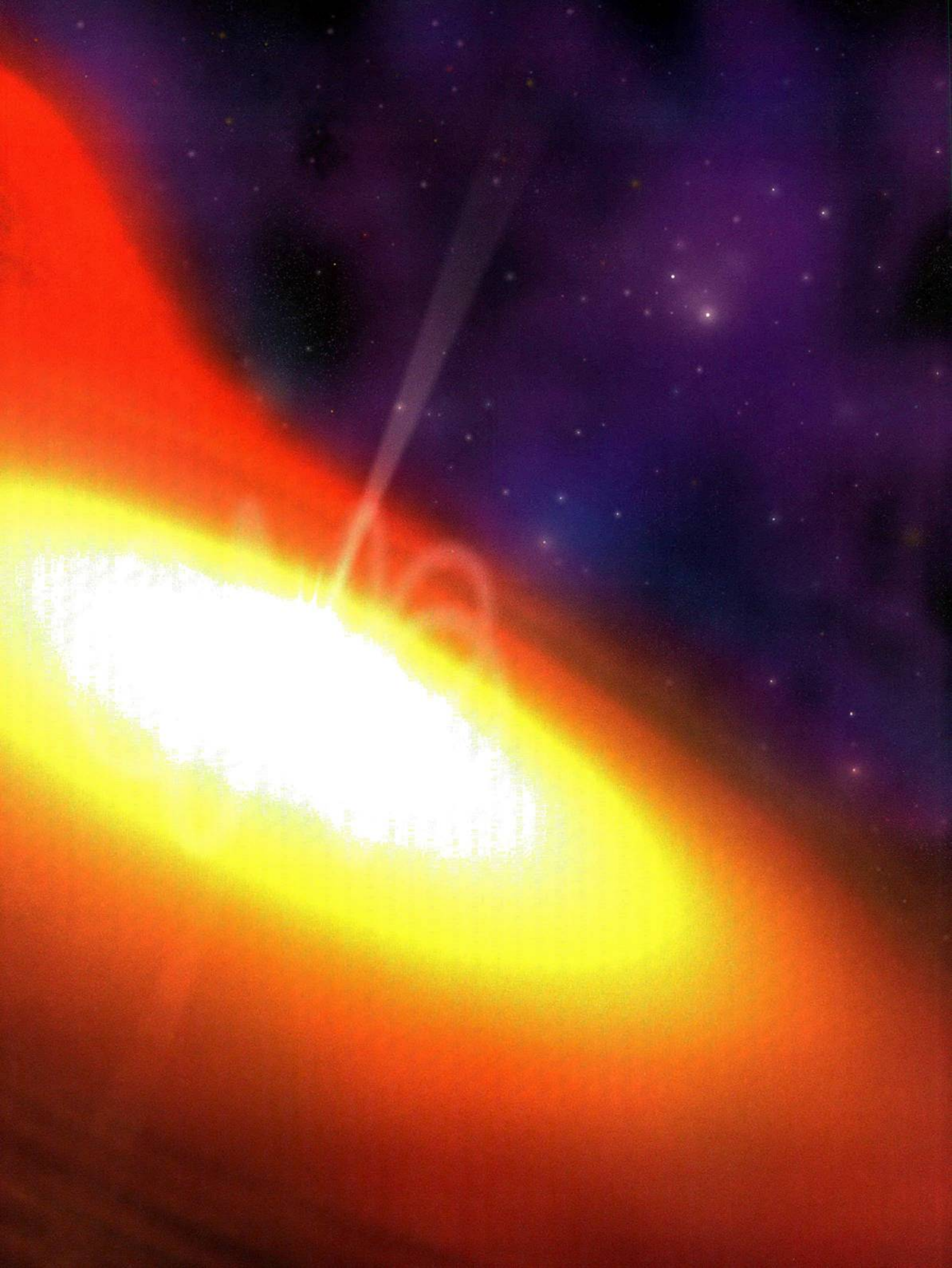
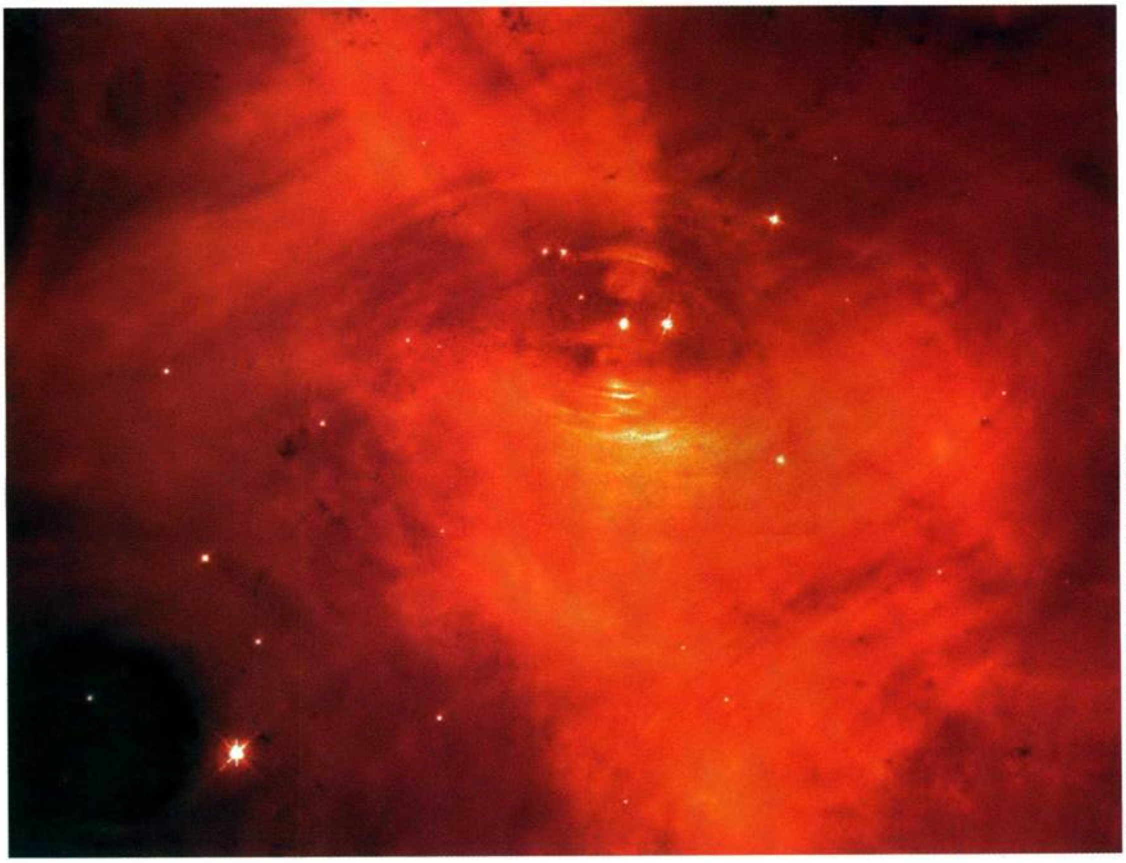
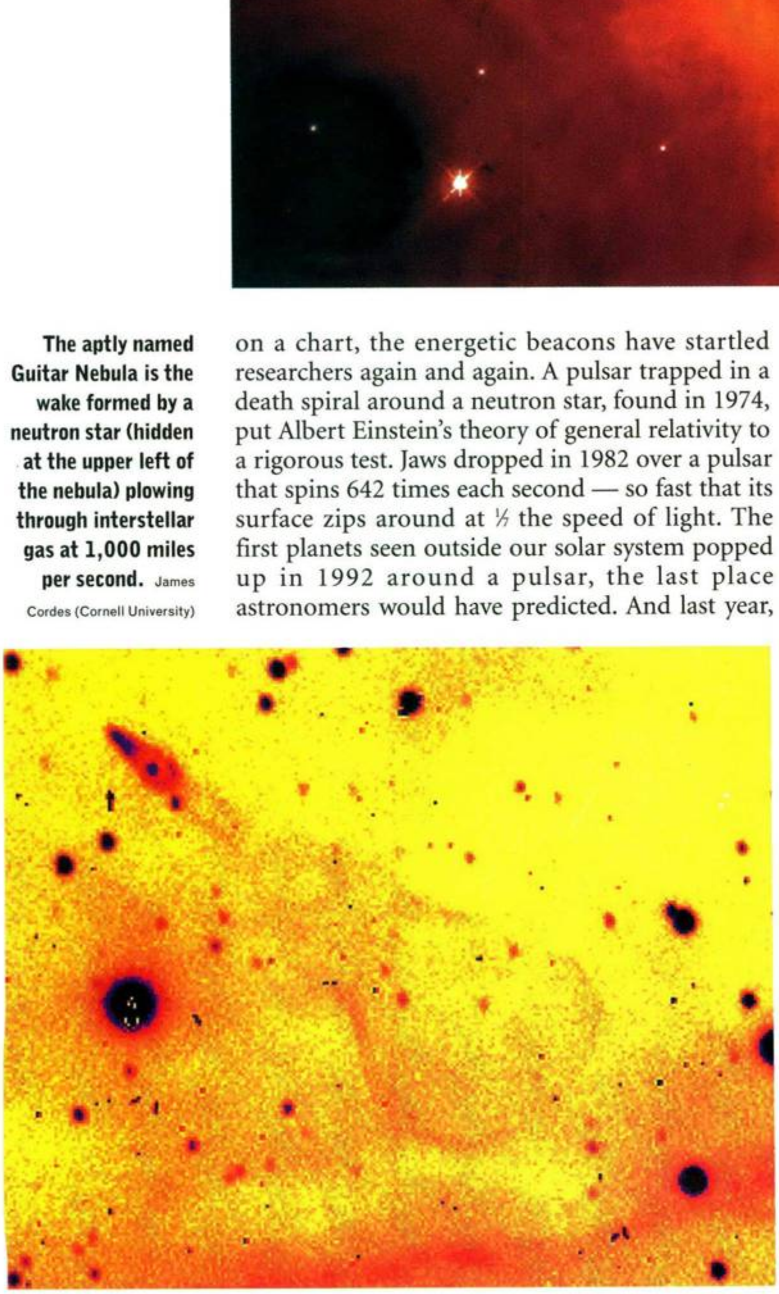




Jeff Hester and Paul Scowen (Arizona State University) and NASA

Spinning 30 times a second, the Crab Nebula pulsar (the left of the two stars at upper center) is the remnant of a star that exploded nearly a thousand years ago.

on a chart, the energetic beacons have startled researchers again and again. A pulsar trapped in a death spiral around a neutron star, found in 1974, put Albert Einstein's theory of general relativity to a rigorous test. Jaws dropped in 1982 over a pulsar that spins 642 times each second — so fast that its surface zips around at ⅕ the speed of light. The first planets seen outside our solar system popped up in 1992 around a pulsar, the last place astronomers would have predicted. And last year, researchers spotted a neutron star threaded by what may be the strongest magnetic field ever seen — a peculiar beast called a "magnetar."



The aptly named Guitar Nebula is the wake formed by a neutron star (hidden at the upper left of the nebula) plowing through interstellar gas at 1,000 miles per second. James Cordes (Cornell University)

But pulsars have value beyond these surprises. Astronomers use them to trace the gases and magnetic fields that permeate our galaxy. Further, they may help physicists detect gravitational waves, ghostly ripples in the fabric of space-time created by the most energetic events in the universe. This mind-bending research hinges upon the key signature of pulsars: rates of rotation predictable to within a few parts per quadrillion. That's 15 decimal places, a precision that rivals the best atomic clocks on Earth.

"That is the most astounding property of pulsars," says astronomer Andrew Lyne of the University of Manchester in England. "It's quite remarkable that we can learn in great detail about their interiors, the shapes and sizes of their orbits, and the existence of gravitational radiation, even though they are just 20 kilometers across and thousands of light-years away."

LITTLE GREEN MEN?

The pulsar tale dates to 1934, when astronomers Walter Baade and Fritz Zwicky theorized that a supernova could spawn a neutron star from the ashes of an ordinary star. "That idea must have seemed completely wacky at the time, but it was prophetic by more than 30 years," says astrophysicist Vicky Kaspi of the Massachusetts Institute of Technology. As with so many advances in astronomy, the discovery of pulsars came when scientists weren't looking for it.

Astronomer Antony Hewish of Cambridge University in England constructed a large antenna in 1967 to study the twinklings of celestial objects at radio wavelengths. In August, a month after the survey began, student Jocelyn Bell noticed odd fluctuations in the signals at about the same time each day. Hewish chalked it up to local noise, but then Bell observed that the source was fixed relative not to Earth, but to the stars. By November, a faster data recorder revealed a shocking pattern: regular pulsations every 1.33731109 seconds. The initial name for the source, LGM-1 for "Little Green Men," reflected the team's concern that it might be an extraterrestrial signal. But in February 1968, Hewish announced that the eerie blips probably came from "stable oscillations of white dwarf or neutron stars."

Later that year, astronomers found the famous Vela and Crab pulsars, both embedded within the remnants of supernova explosions. Only objects as compact as neutron stars could explain their rapid-fire pulsations, nearly 30 times per second in the Crab's case. Baade and Zwicky were vindicated, and Hewish shared the 1974 Nobel Prize in Physics — an honor many felt Bell also should have received.

By now, astronomers have spotted about 1,000 of these stellar timepieces, mostly within our galactic backyard — a few thousand light-years from Earth. A new survey of the Southern Hemisphere sky with the 64-meter Parkes Radio Telescope in New South Wales, Australia, is adding hundreds of pulsars to the list. The telescope finds about one pulsar an hour — an unprecedented rate according to survey codirector Richard Manchester of the Australia Telescope National Facility. An international team has devised new ways to extract the pulsars' weak blips from the din of radio noise spewed by satellites, computers, and the rest of civilization.

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The survey's quarry comes in two main flavors. The concussive deaths of giant stars in supernovae forge most pulsars by packing the mass of one or two suns into crushed cores the size of Mount Everest. A star's lazy spin cranks up to 60 times per second or more during the collapse, while magnetic and gravitational fields grow a trillion times more intense than Earth's.

A new pulsar stores huge amounts of energy in its rotation. As the spin slowly winds down, this energy gets converted into particles and radiation. The pulsar drives charged particles along its magnetic field lines with forces that put atom smashers on Earth to shame. These particles approach the speed of light above the pulsar's surface, radiating energy in great spouts along the two careening magnetic poles. "It's a messy, complicated, relativistic environment," says physicist Fred Rasio of MIT. "It quickly becomes hopeless to understand from first principles how pulsars produce their energy." Most of the radiation cascades into space as gamma rays, x rays, and visible light. Only about one part in a million is at radio wavelengths, but a laser-like process amplifies those photons into coherent pulses that telescopes can see.

The second kind of pulsar gets a new lease on life as a recycled object. Ordinary pulsars shut down after tens of millions of years when their spins subside to once every two or three seconds. But if an old pulsar has a companion star, it can

THE PULSAR TOOLBOX

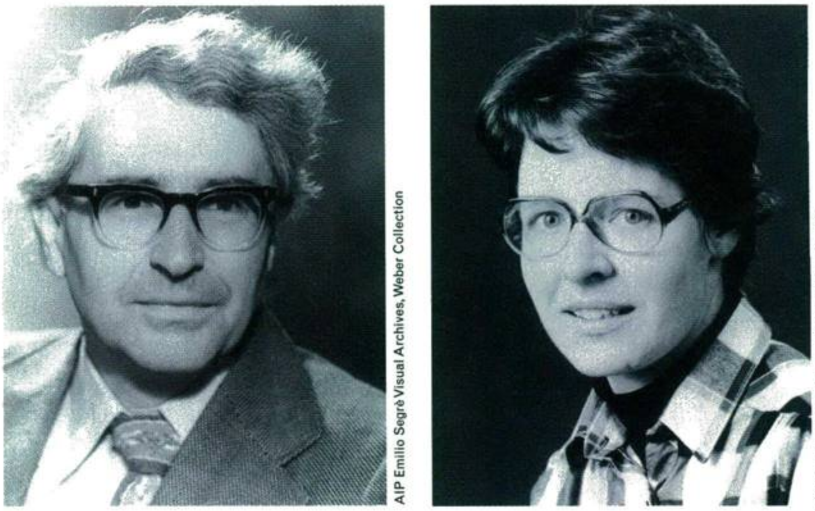
Pulsars freckle space in droves, projecting shafts of energy that astronomers use to probe the Milky Way. For example, they reveal interstellar "weather" by illuminating electrons in the thin gas between stars. Electrons spread a pulsar's radio waves from a sharp click into a time-delayed "chirp." The width of that chirp depends on the density of electrons between the pulsar and Earth. Measuring those dispersions for many pulsars of known distances leads to a model of ionized gas throughout the galaxy.

The Milky Way's magnetic fields also alter the polarization of a pulsar's signal, splitting it just as layers of mica create double images. Further, clouds and other irregularities among the stars scatter a pulsar's beam on its journey to Earth. Combining these subtle clues, says Andrew Lyne of the University of Manchester, yields "a picture of the dynamics of gas and magnetic fields in the interstellar medium."

Pulsars also serve as tools to find planets in weird places (see "Second Chance Planets," January 1996). In 1992, astronomers Alex Wolszczan of Pennsylvania State University and Dale Frail of the National Radio Astronomy Observatory spied the first planets outside our solar system by timing the tiny fluctuations of a speedy pulsar in the constellation Virgo. Two planets a few times larger than Earth, and possibly two others circling the same neutron star, form the only known pulsar family of planets, Wolszczan says. Astronomers have since exposed numerous planets around ordinary stars, but current methods limit those searches to bodies at least as massive as Jupiter.

One might think astronomers could use the number of pulsars to reveal how often supernovae explode, thus constraining the life histories of stars. However, pulsar surveys tend to find the closest and slowest moving pulsars — not to mention the ones whose beams flash toward Earth. "The observed population is incredibly biased, so it's difficult to estimate how many pulsars the galaxy contains," says Vicky Kaspi of MIT. According to Lyne, best guesses range from 200,000 to 500,000. When combined with the average pulsar lifetime of 10 to 20 million years, this yields a birth rate of about one per century in the Milky Way — close to the estimated supernova rate.

be revived when the companion ages and expands into a bloated gassy ball. Some of that matter falls onto the neutron star, whirling it back up to incredible rates of at least 100 spins per second and flinging x rays across the galaxy.



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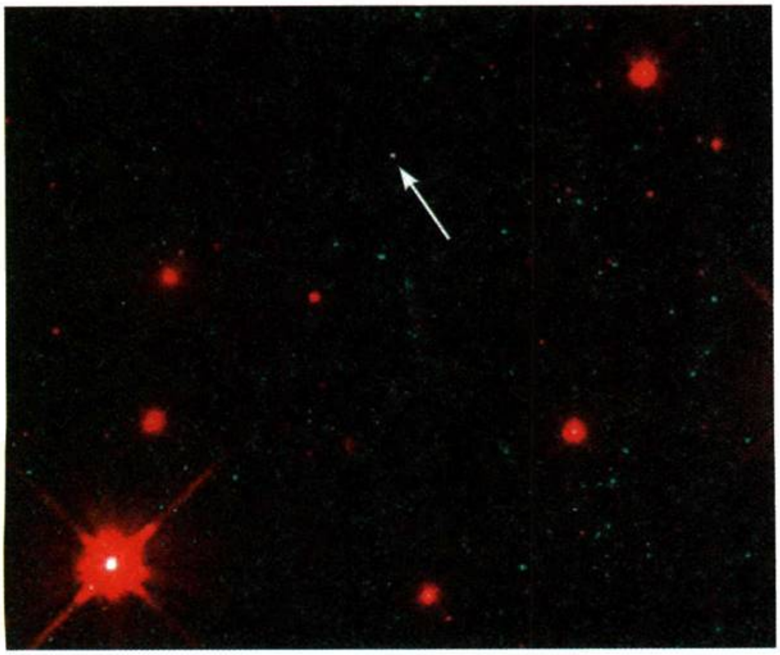
Antony Hewish (left) and Jocelyn Bell discovered the first pulsar in 1967, when they serendipitously detected a celestial radio signal that repeated every 1.337 seconds.

Millisecond pulsars are colder and more stable than their freshly minted cousins from supernovae. For that reason, they make the most accurate clocks in the cosmos, says physicist Stephen Thorsett of Princeton University. "There's something very appealing about taking a solar mass, putting it into a 20-kilometer package, and spinning it 600 times a second," he says. "They are ideal clocks, much like those you would find in one of Einstein's Gedanken [thought] experiments."

The pulsar population grew stranger with another recent finding. Astrophysicist Chryssa Kouveliotou of NASA's Marshall Space Flight Center and her colleagues argued in the May 21, 1998, *Nature* that they had spotted a "magnetar." X-ray analysis hints that an intense magnetic field, 100 times stronger than those around typical pulsars, girdles a neutron star 40,000 light-years away. The field exerts a powerful drag on the star's surface, slowing it to a mere one spin every 7.5 seconds. Magnetic stresses also may crack the brittle surface of the cooling neutron star and send shock waves racing into space. These weird objects would grind to a near halt after only thousands of years. "There must be millions of these in the galaxy, dead and invisible to us," Kouveliotou says.



Hubble captured this first visible light image of an isolated neutron star. The star is no more than 17 miles across and glows at 1.2 million degrees Fahrenheit.

Fred Walter (SUNY at Stony Brook) and NASA

The most tantalizing pulsar of all has yet to appear, if it even exists. Astronomer John Middleditch of Los Alamos National Laboratory believes a new pulsar churns outrageously fast — 467 times per second — at the heart of the remnant blasted 12 years ago by Supernova 1987A in the Large Magellanic Cloud. After a possible detection in 1992, the pulsar vanished. At its great distance of 170,000 light-years, says Middleditch, "it undoubtedly would be very faint." Blobs of debris also may screen the pulsar from view. Astronomers would jump for joy to study a pulsar so soon after its cataclysmic birth.

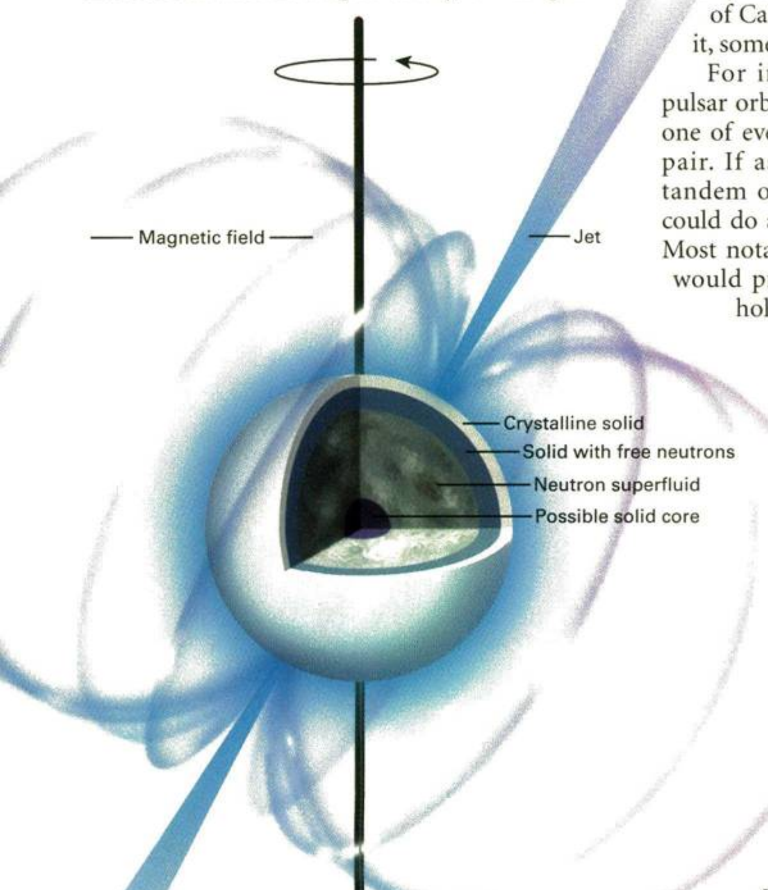
SPEEDING BULLETS

A pulsar's explosive entrée into the universe can propel it into space at eye-popping speeds. The average pulsar zips through the Milky Way Galaxy at 900,000 miles per hour (400 kilometers per second), quick enough to escape the galaxy's gravitational maw. Researchers have clocked the fastest one, zooming at the tip of the fancifully named Guitar Nebula, at four times that speed. "That's the fastest star we know about in the galaxy," says astronomer James Cordes of Cornell University. In this way, galaxies hurl tens of millions of neutron stars into intergalactic space during their lifetimes, he says.

By calculating the range of pulsar velocities and searching for even faster ones, Cordes hopes to shed light on the "murky physics" of a supernova's collapsing core. Some unevenness in the collapse, perhaps caused by turbulence in the dying star, must spurt from the core like a cosmic watermelon seed. Blasts of subatomic neutrinos from a supernova are so titanic, Cordes notes, that if even a minuscule fraction of them erupt preferentially to one side, that would be enough to kick the pulsar on its way.

Another curiosity of pulsar motions promises to reveal more about their wild interiors. Every so often a young pulsar speeds up very slightly, by about one part in a billion. Astronomers think some of these glitches can be explained by "starquakes" — a slight fracture in the pulsar's crust as it relaxes from a squashed shape, caused by an extremely fast spin, to a rounder shape. The fact that we can detect such a starquake on Earth is amazing, for it may result from a change in the star's radius of less than 1/100 of a millimeter.

Most pulsars return to their previous spin rate over a period of several days to months, says Andrew Lyne. "It's like the physics of an uncooked egg," he says. "If you spin an egg on a smooth surface and stop it briefly, it will spin up again when you remove your finger. By watching how that occurs, you can learn about the viscosity of the fluid inside the egg and its coupling with the shell." For pulsars, physicists wish to probe the sea of neutrons that underlies the rigid crust. That dense neutron sea probably is "superfluid," meaning that it swirls endlessly with no friction.



Even farther down, in a pulsar's dark heart, intense pressures may squeeze the neutrons into a soup of quarks. Such a "soft" interior would limit the maximum mass of a neutron star to perhaps 1.5 times that of the sun, says physicist Ralph Wijers of the State University of New York, Stony Brook. A "stiff" interior of solid neutrons, on the other hand, might permit neutron stars up to 2.5 times the sun's mass. So far, based on studies of pulsars in binary systems, they seem to cluster around 1.35 solar masses. "It may be that the larger ones collapse into black holes, for reasons that we don't understand," Wijers says.

BLACK HOLES AND GRAVITY WAVES

Many astronomers think the best pulsar tricks are yet to come. "Pulsars seem to surprise us at least every couple of years," says Donald Backer of the University of California, Berkeley. "If we can think about it, someday we'll probably find it."

For instance, all await the discovery of a pulsar orbiting a black hole. Theories suggest that one of every 1,000 pulsars should exist in such a pair. If astronomers find a pulsar-black hole tandem oriented nearly edge-on to Earth, "We could do all kinds of amazing things," says Rasio. Most notably, the pulsar's precisely timed signals would probe in stunning detail how the black hole warps the space-time continuum in its neighborhood. Unfortunately, odds are that astronomers will need to spot at least 10 such binaries before one happens to have just the right alignment.

Further, millisecond pulsars may serve as far-flung detectors of gravitational waves, vast ripples of space-time unleashed by collisions between black holes and other violent events. Defects in the structure of space in the very early universe, caused by hypothetical entities called cosmic strings, also might have set off long-lasting gravitational waves. If such waves drifted past, says Stanford's Roger Romani, they would temporarily distort space and change the distance between us and faraway pulsars. That would make the radio pulses arrive either earlier or later than expected, by incredibly tiny intervals. In this way, Romani says, "We can use pulsars as cosmic range finders."

Pulsars would have delighted Einstein had he lived to see them join the cosmic menagerie. For these exquisite clocks are among the universe's most extreme objects, and they are perhaps the best natural labs for subjecting his theories of relativity to ever more stringent tests.

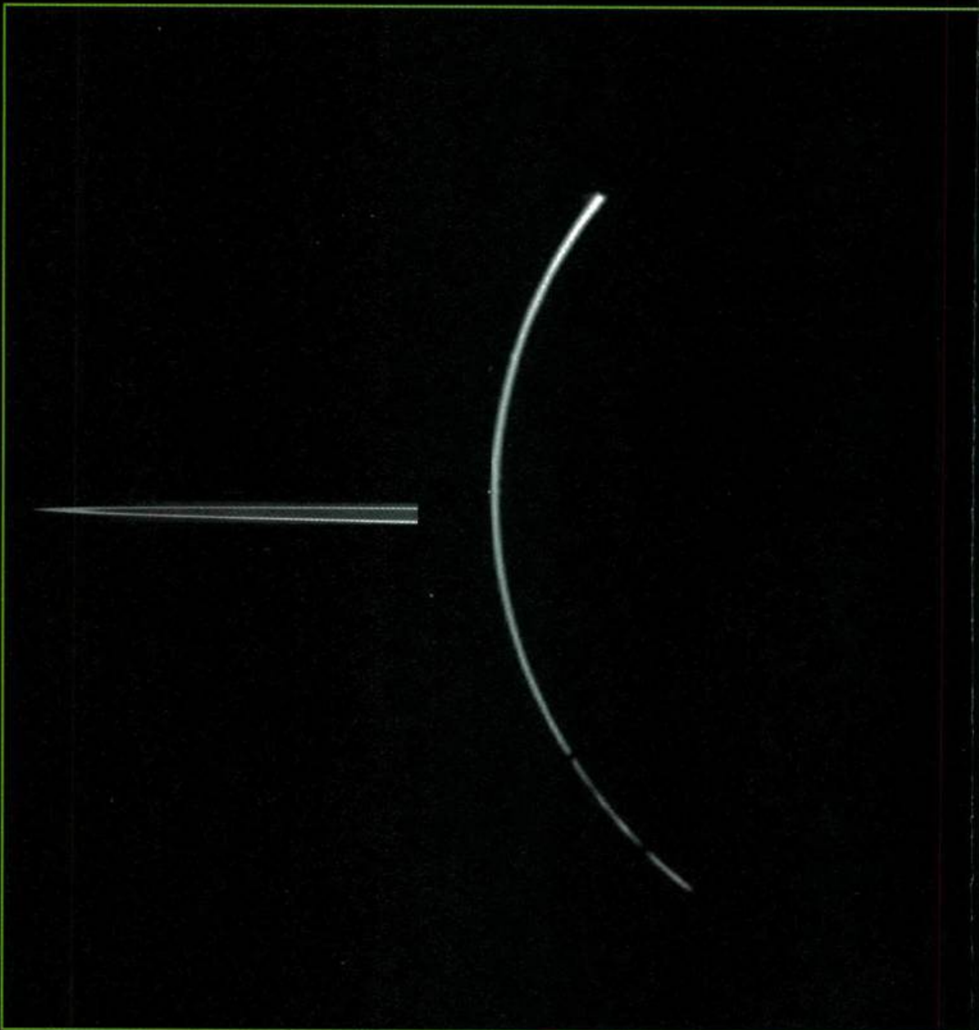
Robert Irion is a freelance science journalist in Santa Cruz, California. He wrote "Exploding Stars Tell All" in the November 1998 issue.

A pulsar operates in much the same way as a lighthouse. As a pulsar spins, energetic jets beamed from its magnetic poles may sweep past Earth. The jets radiate as protons and electrons are accelerated to near the speed of light by the pulsar's intense magnetic field. Although scientists aren't sure what the inside of a pulsar is like, they suspect a crystalline solid surrounds neutrons in various exotic states.

Astronomy: Elisabeth Rowan

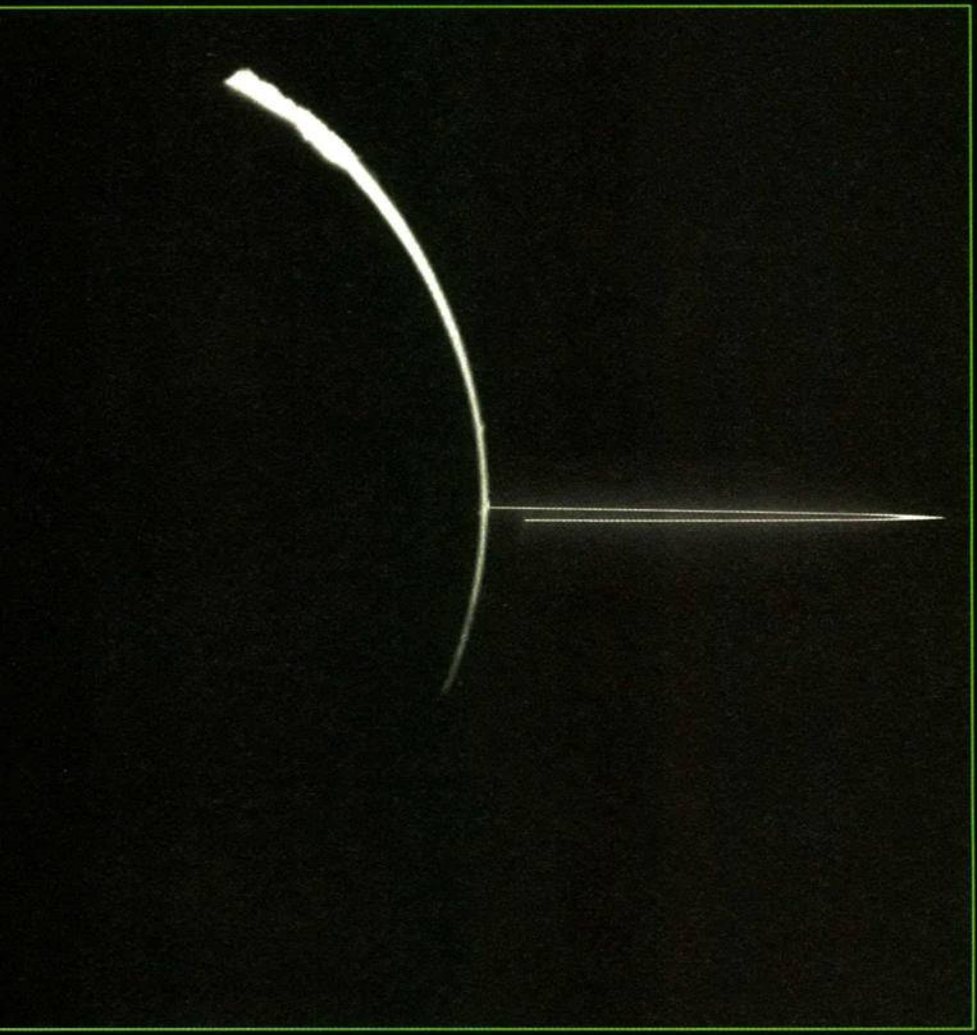
JUPITER'S GO

Surprised astronomers using the Galileo spacecraft may have discovered the origin of Jupiter's rings.



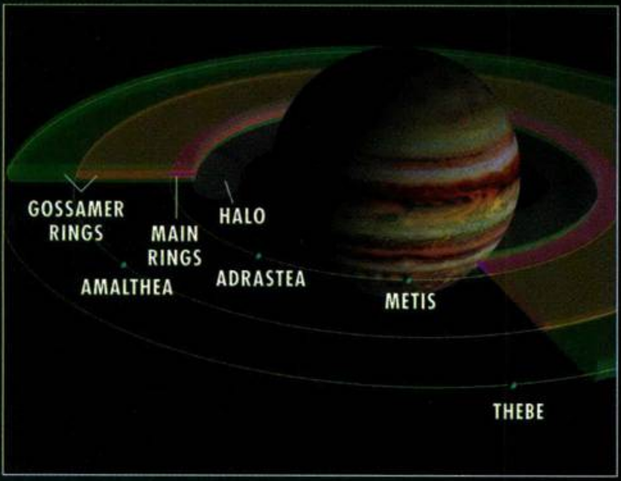
NASA/JPL

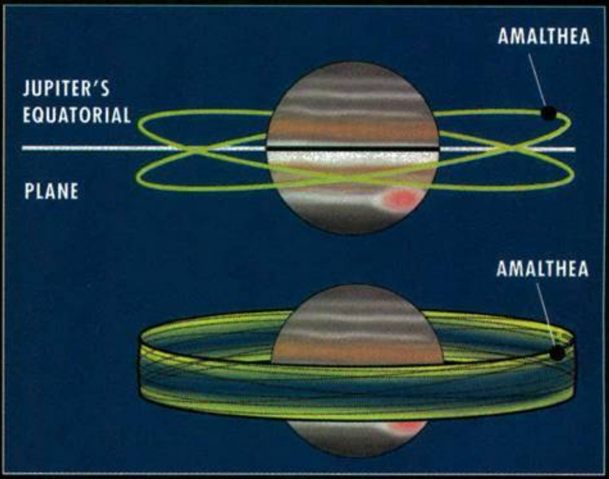
SSAMER RINGS

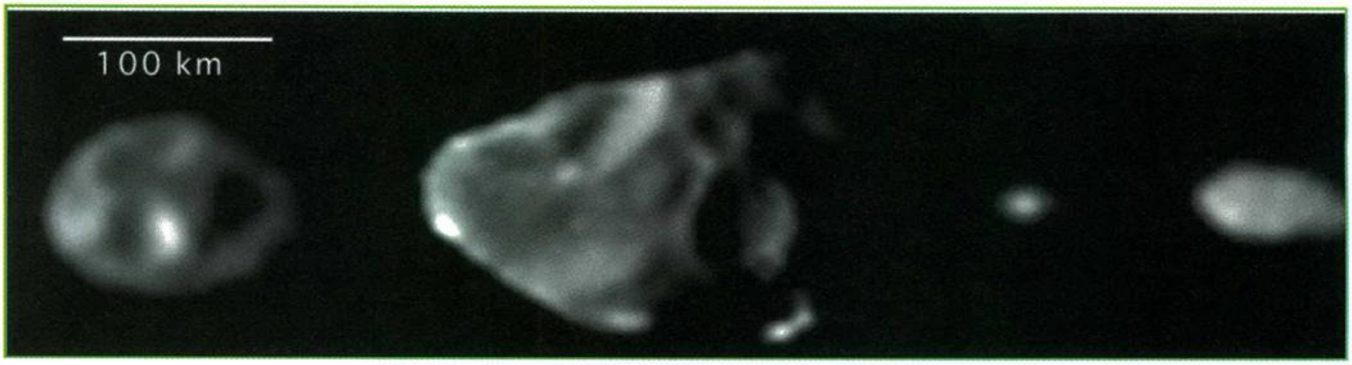


Twenty-two years ago astronomers thought Saturn and Uranus were the only ringed planets in the solar system. Then NASA's Voyager 1 and 2 spacecraft revealed in 1979 that Jupiter had them, too, and Neptune's rings were discovered in 1985. Now, stunning images recently taken by NASA's Galileo spacecraft have not only revealed Jupiter's rings in far greater detail than ever before, but also offer strong circumstantial evidence of how the rings got there in the first place. "These images provide one of the most significant discoveries of the entire Galileo imaging experiment," says National Optical

This mosaic of Jupiter's ring system was acquired by NASA's Galileo spacecraft when the sun was behind the planet and the spacecraft was in Jupiter's shadow, aimed toward the sun.







A schematic view, upper left, of Jupiter's ring system shows the geometry of the rings and their relation to the small, inner satellites, the source of the dust that forms the rings. The gossamer rings include Amalthea's orbit and are as thick as Amalthea's excursion off Jupiter's equatorial plane. NASA/JPL

NASA's Galileo spacecraft recorded images, lower figure, of the innermost satellites of Jupiter; from left, Thebe, Amalthea, Adrastea, and Metis. NASA/JPL

Astronomy Observatories astronomer Michael Belton.

Galileo, which is in the middle of a two-year extended mission to observe Jupiter's moon Europa, imaged Jupiter's faint outer ring, known as the gossamer ring, with remarkable clarity. This ephemeral ring, which was barely discerned by Voyager 2, was found by Galileo to be made of two dusty rings of debris. On closer inspection, surprised astronomers also discovered that the rings were trailing from the orbits of two small jovian moons: Amalthea and Thebe. These satellites orbit Jupiter in paths that tilt slightly relative to the gas giant's waist. In an elegant twist, the vacillating paths of Amalthea and Thebe correspond to the thickness of Jupiter's gossamer rings. "Since the particles have the same orbit and tilt, they are probably born of the satellites," says Cornell University astronomer Joseph Burns.

After the Voyager flybys, Burns and others hypothesized that fragments of comets or asteroids hit the small moons, kicking up dust that coalesced into the rings. Galileo images support this idea: They show that the moons have heavily cratered surfaces. "Obviously the moons are getting bashed all of the time," says Maureen Ockert-Bell, a research associate at Cornell University.

When fast-moving meteoroids hit the small moons, the weak gravitational force fields on the moons can't hold the flying dust particles. As a consequence, the jettisoned particles waft into space, but Jupiter's powerful gravity corrals them. The dust particles trail in the wakes of their parent moons and settle gracefully into orbits around Jupiter.

Astronomers think that Jupiter's main ring also consists of impact debris, in this case flung from the moons Adrastea and Metis. "We can see that the satellite Adrastea sits at exactly the edge of the main ring," says Burns.

The inner halo may have formed differently, however. The dusty particles orbiting Jupiter are themselves electrically charged.

As the particles drift inward, toward Jupiter, they encounter its magnetic field, which jostles them. This phenomenon has created a halo of scattered dust more than 15,000 miles (24,000 km) thick. The main ring, by comparison, is only 18 miles (29 km) thick.

Astronomers will continue to observe the rings. Their findings could help them understand the evolution of another flattened disk of debris orbiting a massive central body — our early solar system. "These rings are labs in which we can look at the dynamics going on today that used to go on way back when," says Burns. — *Tracy Staedter* ■

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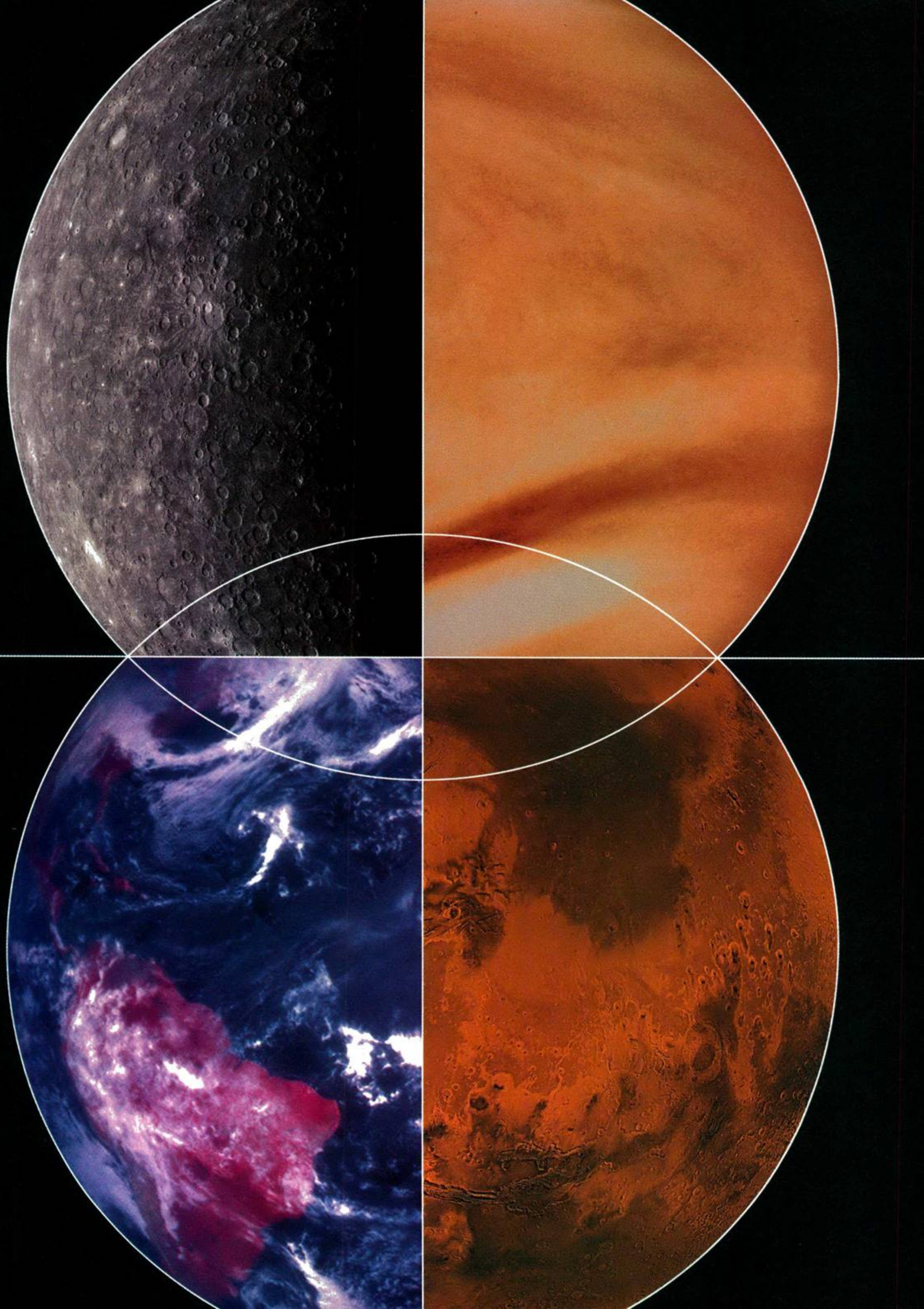


Planetary Face-off

Tectonics and impacts disfigure Mercury, Venus, Earth, and Mars, but the terrestrial planets have faces that any geologist can love.

by Thomas R. Watters

Mercury, Venus, and Mars are classified as terrestrial planets (*terra* is Latin for Earth) because they have rocky, silicate-rich surfaces. They may be in the same family, but each individual has distinct traits that make it unique. Is it possible that the same geologic forces shaped each of the terrestrial planets in different ways?

This question inspires me and other planetary scientists and geologists. We are combining what we are learning from planetary probes with our greater understanding of the geologic processes on Earth to explain how the solar system's planets and moons may have evolved.

FIERY BIRTHS

By studying debris left over from the formation of the solar system that has fallen to Earth as meteorites, planetary scientists have traced the evolution of the terrestrial planets to their births. The planets began coalescing out of a disk of gas and dust orbiting the sun about 4.6 billion years ago. It was a fiery infancy of growth by bombardment. The accretion of silicate- and metal-rich planetesimals created huge amounts of heat. Gravity compressed and heated the planets' interiors, and the decay of radioactive elements added even more heat. The planets melted and differentiated: Metals, particularly iron, sank into molten cores, and the less dense silicates floated, forming crust.

Clockwise from top left, Mercury, Venus, Mars, Earth. NASA/JPL

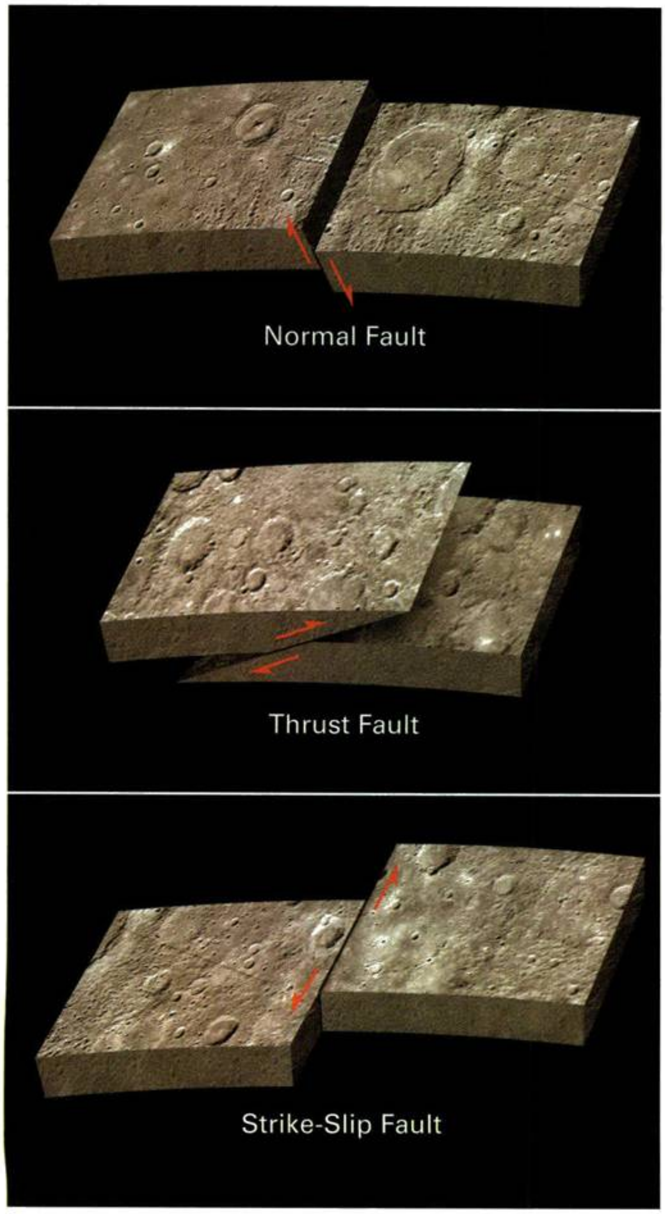
The subsequent cooling influenced how their crusts evolved. The planets' loss of heat is reflected by two processes; volcanism, the eruption of lava, and tectonism, the reshaping of the surface by the movement of crust. The dominant cooling mechanism on Earth is plate tectonics, which involves the movement of eight large plates and a few dozen smaller ones. The motion is driven from beneath by convection within the mantle. Hot magma rises and erupts along mid-ocean ridges, spreading centers on the seafloor, forming new oceanic crust. As new seafloor crust forms, it pushes out, cools, and thickens. Eventually, mature oceanic crust reaches the edges of thicker, more buoyant continental crust, where it sinks back into the mantle. These areas are called subduction zones and create deep-ocean trenches. The result on Earth is a topography sharply divided between highlands (the continents) and lowlands (the ocean basins).

PLATES AND FAULTS

The movement of Earth's plates has caused some of the greatest disasters in human history. It also inspires Hollywood's film industry. California's infamous San Andreas fault is a "strike-slip fault." It is a place where the Pacific plate, an oceanic plate, and the North American plate, a continental plate, meet and slip past one another.

When two continental plates collide, mountain ranges like the Himalayas are thrust up. The movement of plates away from one another forms rift valleys like the East African rift. When oceanic plates collide with continental plates, mountain ranges like the Andes and volcanoes like Mt. Fuji form. Plate tectonics concentrates most of the volcanoes, earthquakes, and other tectonic features along plate margins rather than scattering them evenly throughout Earth's crust.

Tectonism, the movement of a planet's crust in response to forces or stresses, often is reflected in three types of faults . *Astronomy*: Elisabeth Rowan



MOON-LIKE MERCURY

In 1974, Mariner 10, the first and only planetary mission to Mercury, discovered that the innermost planet looks like Earth's moon. (Mariner 10 returned images of only about 45 percent of the mercurian surface. Scientists have proposed future missions to map and study the entire surface.) The part that has been studied has heavily cratered uplands, moderately cratered plains interspersed throughout the uplands, and smooth lowland plains. Although Mercury doesn't have mountain ranges or volcanoes that would suggest the motion of crustal plates, it has other amazing tectonic features.

Mariner 10 discovered long, sinuous ridges, called lobate scarps. My colleagues and I think these scarps are evidence that Mercury's crust contracted, forming "thrust faults." These scarps often cut pre-existing impact craters. They also are evenly distributed on Mercury rather than concentrated in belts or zones. This distribution suggests that plate tectonics did not form these features. Instead, it strongly suggests that Mercury has a single, continuous plate.

How did the scarps form? The planet is about one-third of Earth's size and has six percent of the mass. In general, most of the heat in small planets is lost by conduction through a thick crust, rather than by convection. We think that as Mercury cooled and contracted, its crust shrank. Adding up the crustal shortening reflected in the scarps suggests that Mercury's diameter may have decreased by roughly 0.6 mile (1 km). The shrinkage occurred sometime after the period of heavy bombardment ceased about 4 billion years ago.

MARTIAN SCARPS

Mars is larger than Mercury — a little more than half the size of Earth and about 11 percent of the mass. The Mariner and Viking missions revealed that Mars's surface is much more complex than Mercury's.

Despite its diminutive size, Mars has some of the most impressive land forms in the solar system; the biggest volcanoes, some of the largest impact basins, vast canyons, and outflow channels that suggest the planet might once have had flowing water.

Many of these features are associated with a topographic bulge called the Tharsis rise, which dominates the western hemisphere of the planet. The Tharsis rise may have been formed by an upwelling of mantle material and a buildup of crust from episodes of flood volcanism. Here, huge shield volcanoes tower above its broad plains. These plains have stretched apart and cracked, forming graben, a pull-apart feature that looks like a trench. In some cases the crust is compressed and buckled perpendicular to the trenches, forming wrinkle ridges. The Valles Marineris, a huge canyon system long enough to span the United States, cuts across the plains of the Tharsis rise. Valles Marineris is a rift in the martian crust, similar to a rift valley on Earth, only much larger.

The largest known shield volcano in the solar system, Olympus Mons, rises about 16 miles (26 km) above the surrounding plains of the Tharsis region. In contrast, Hawaii's Mauna Loa, the largest shield volcano on Earth, rises only 5.7 miles (9.1 km) above the ocean floor. Why is Olympus Mons so much larger? The shield volcanoes in the Hawaiian chain were formed by magma rising from a single mantle hot spot. The hot spot remains stationary beneath the moving Pacific plate. When the plate moves, another Hawaiian volcano forms. On the other hand, Olympus Mons and other Tharsis volcanoes grew much larger because the plate on which they sit apparently didn't move. The martian volcanoes grew until the hot spots themselves fizzled out. Such hot-spot volcanism represents another important cooling mechanism.

The relatively small size of Mars, its colossal shield volcanoes, and the scattered nature of its tectonic features, all suggest that Mars — like Mercury — is a one-plate planet with a relatively thick, stationary crust. However, there is a prominent topographic feature on Mars that may not fit this convenient model.

THE DIVIDED CRUST

The topography of Mars, like Earth, is divided between highlands and lowlands. A steep escarpment marks the boundary in the eastern hemisphere of Mars. It is 1.6 miles (2.5 km) or more high, and known as the crustal dichotomy. New topographic data returned by Mars Global Surveyor indicate that these lowlands are as smooth as the sediment-covered abyssal plains of Earth's seafloor. Some planetary scientists believe that the northern lowlands held a vast ocean. Others think impacts might have excavated the lowlands. Yet another idea is that the ancient highland crust was eroded from below by convection currents in the mantle.

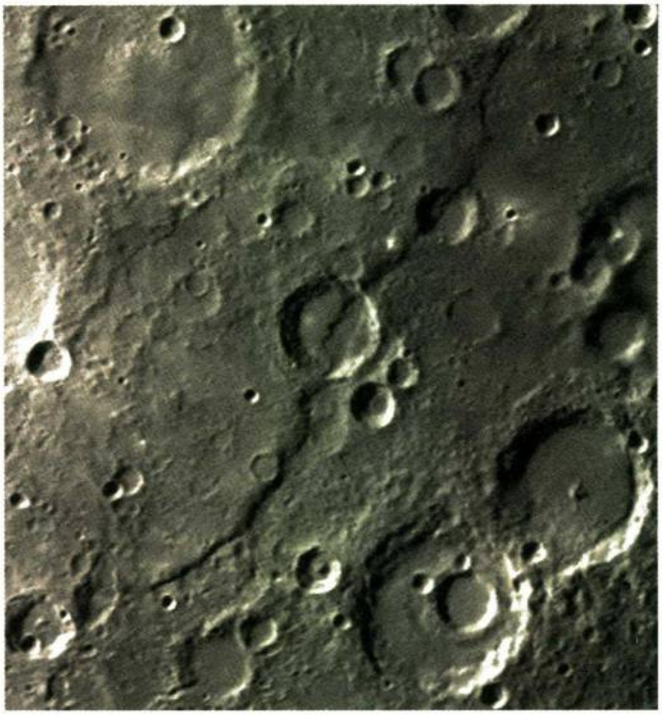
A more recent idea is that plate tectonics may have formed the lowlands. In this model, pre-existing highland crust was removed by a mechanism analogous to seafloor spreading. That process could have produced the existing thin, lowland crust. The dichotomy boundary between the highlands and lowlands could mark the location of relic plate margins.

Landforms that look like mercurian scarps also are found on Mars. Many scarps are found near and parallel to the dichotomy boundary. These scarps, as well as other cracks and graben along the escarpment, may be evidence of a tectonic origin of the crustal dichotomy. The Mars Global Surveyor is scheduled to begin its primary mapping mission in March 1999, and its high-resolution images and topographic data will help us determine what, if any, role plate tectonics played in shaping the martian surface.

CLOSEST NEIGHBOR

If plate tectonics did not shape Mercury, and it is not obvious on Mars, surely it is present on Earth's most similar sibling, Venus. Although Venus is only slightly smaller than Earth and has 80 percent of the mass, the Venera, Pioneer-Venus, and Magellan missions revealed features on the planet that are both familiar and strange. Venus has highlands and lowlands, similar to Earth's continents and ocean basins. But much less of Venus is as high as Earth's continents. The highland landmass, Ishtar Terra, is larger in area than the continental United States, and has rugged mountain ranges in its interior and on its margins, not unlike continents on Earth. One of these mountain ranges, Maxwell Montes, rises nearly 6.8 miles (11 km) above the average planetary radius, higher than Mount Everest. Regions of highly deformed terrain called tesserae are associated with these mountain belts. The mountains and tesserae were probably formed by the thrusting and stacking of crustal blocks.

Conspicuously absent from the venusian landscape are features comparable to Earth's mid-ocean ridges and deep trenches that reflect subduction, the process by which oceanic plates descend below the edges of continental plates. At the same time, signs of volcanism are everywhere on Venus, including large shield volcanoes. The volcanoes, however, are not concentrated along linear zones as most are on Earth. Instead, they are widely distributed throughout the plains and in some highlands. The expansive volcanic plains that make up much of the lowlands of Venus have been stretched and buckled, forming systems of fractures and wrinkle ridges that are relatively evenly distributed over thousands of square miles.

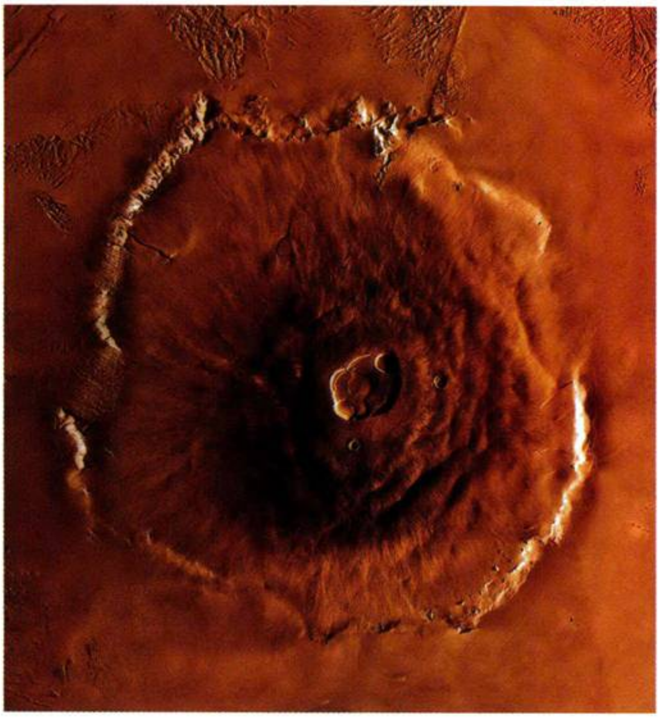


Discovery Rupes, the largest lobate scarp on Mercury, cuts across two pre-existing impact craters. This and other scarps are thought to record contraction of the planet after the end of heavy bombardment.

Mark Robinson/Northwestern University

Another common geologic feature on Venus is called a corona. Rising mantle plumes or diapirs (bubbles of hot magma) are thought to form coronae. As a diapir contacts and lifts the crust it forms a circular to elliptically shaped plateau. This is the source of volcanic eruptions and circular and radial fractures. As the diapir cools, the plateau subsides and forms a circular depression. Rift zones that may extend for thousands of miles are associated with some coronae clusters on Venus.

All these features argue against plate tectonics as the dominant heat-loss mechanism on Venus. They suggest that the planet cooled by conduction through the crust, mantle plumes, and volcanic hot spots. Although coronae are thought by many to exist only on Venus, some of my colleagues and I believe there are examples of these features on Mars and possibly on Earth's yet-to-be-explored seafloor. What other mechanisms for heat loss are possible? One idea, suggested by the young age of the venusian crust (deduced by the relatively small number of impact craters present on the surface), is that global subduction of the crust of Venus may have been episodic and rapid. Global subduction could occur suddenly after interior heat builds up. Or, convection in the mantle that drives plate tectonics may itself be episodic.



Olympus Mons on Mars, the largest volcano in the solar system, is three times higher than Earth's Mount Everest and covers an area the size of Arizona. NASA/JPL

Another suggestion is that plate tectonics was operating on Venus until about 500 million years ago when it simply died out after that time.

MOON GEOLOGY

What about the moons of the solar system? Is there evidence of tectonism and volcanism on these objects? Yes.

Our moon is a little more than one-quarter the size of Earth but has only about one percent of the mass. Like the terrestrial planets, the moon has highlands and lowlands. Heavily cratered highlands comprise about 80 percent of the lunar crust. Most of the lowlands are associated with the moon's large impact basins, which dominate the Earth-facing hemisphere. It is in these impact basins that lunar volcanism and tectonism are concentrated. After the basin-forming impacts, magma, rising from deep fractures, flooded the basin floors and formed the dark-colored lunar maria. The weight of the volcanic fill caused the crust beneath it to subside. The basins formed graben-like trenches on their edges and wrinkle ridges that indicate compression in the center.

Wrinkle ridges are perhaps the most common tectonic features in the solar system. They have been found in volcanic plains on the terrestrial planets. Eastern Washington has analogs to planetary wrinkle ridges. This area, known as the Columbia Plateau, is made up of volcanic plains that have been buckled into a series of ridges. The stresses that buckled these plains are attributed to the motions of the North American and Pacific plates.

Other tectonic features, analogous to scarps on Mercury and Mars, occur in the lunar highlands but are much smaller. These scarps reflect a small amount of crustal shortening. They suggest that the moon, unlike Mercury, did not experience any significant global contraction beyond the period of heavy bombardment, as its interior cooled.

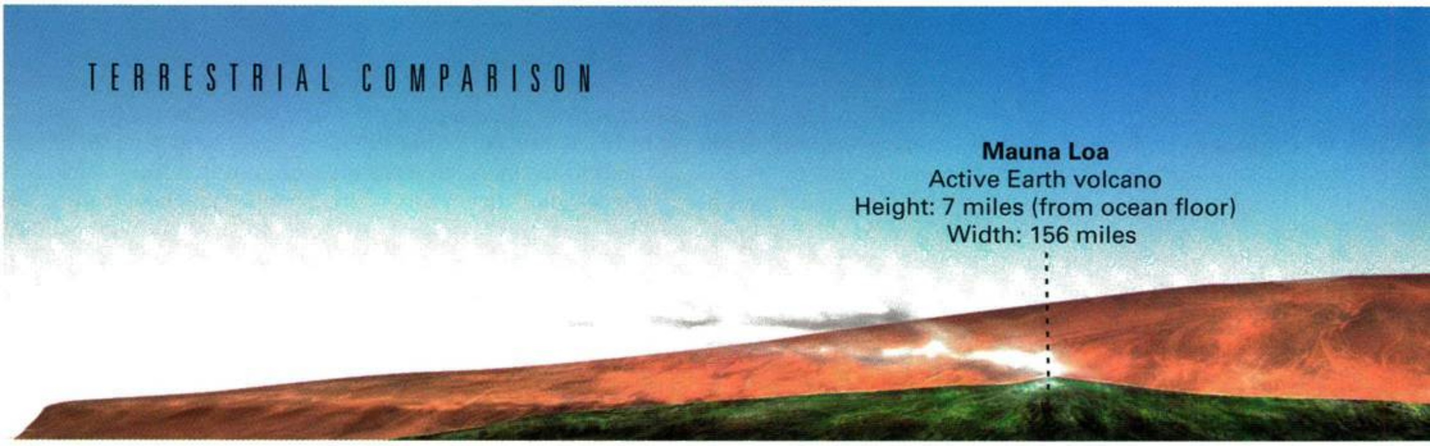
ICE TECTONISM

The Voyager spacecraft provided the first close-up views of the moons of the outer planets. The solid surfaces of many of these planets' moons are composed of water-ice instead of rock. Most of the rock in these icy moons is located in their cores, however many of these moons show evidence of complex tectonic activity.

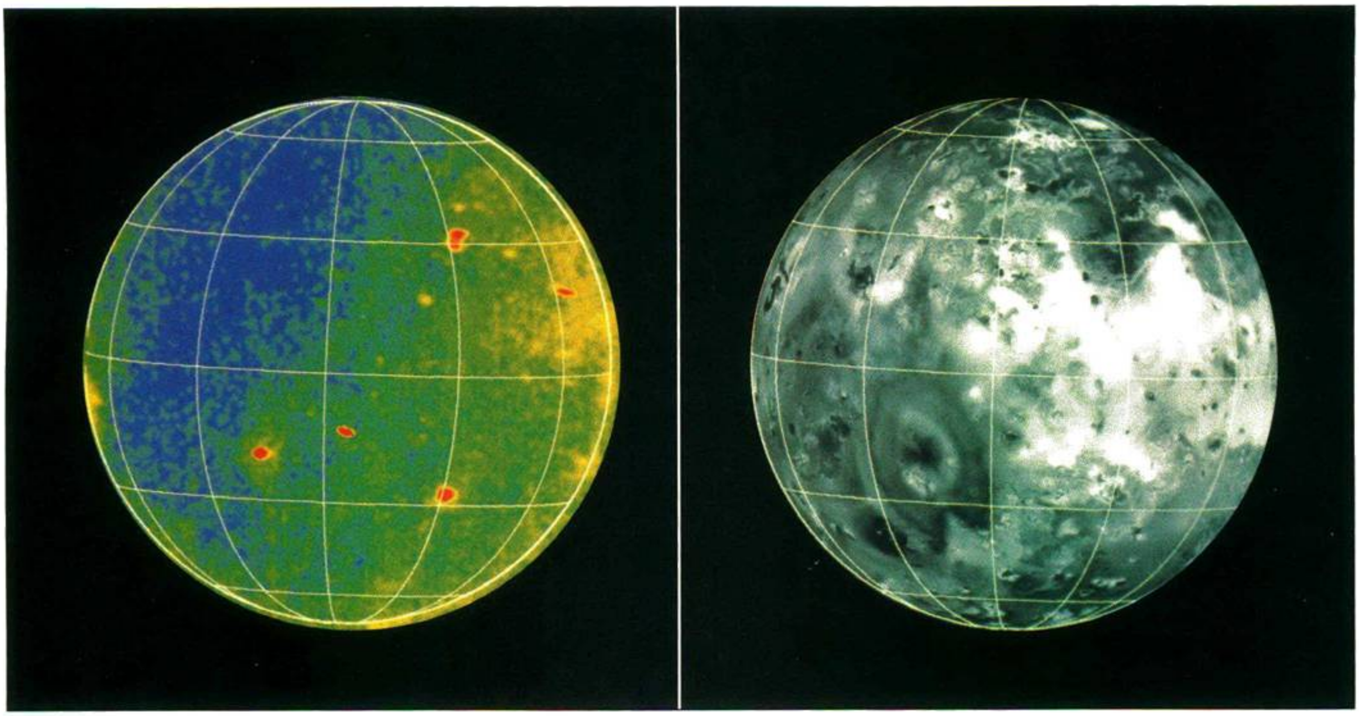
Galileo has returned spectacular high-resolution images of the jovian moons Ganymede and Europa. Ganymede, the largest moon in the solar system, is an ice giant, larger than Mercury. Its surface is covered by a network of parallel grooves that have no analogs on the terrestrial planets. The grooves formed early in the moon's geologic history when the ice crust was stretched, creating fractures and related features. The closer the spacing of the grooves, the thinner the crust was when it was deformed.

Galileo images of Ganymede have 100 times sharper resolution than the best Voyager images. These images have revealed what appear to be several widely spaced grooves in one area. These grooves actually are several tens of closely spaced ridges and troughs. This suggests that Ganymede's crust was very thin when the grooves formed. A thinner crust points to more interior heat in the moon's early history.

Europa is smaller than Ganymede, but not much smaller than Earth's moon. Europa also has a prominent network of surface grooves and ridges. Galileo also revealed evidence of



Olympus Mons would be easy to climb because Mars's gravity is less than Earth's and the slopes of Olympus Mons rise gradually, only a few degrees at its steepest. *Astronomy*: Elisabeth Rowan



Volcanic hot spots and auroral emissions glow, left, on the dark side of Jupiter's moon Io. The Galileo spacecraft image was taken while Io was in Jupiter's shadow. The mosaic at right of 1979 Voyager images is shown with an identical scale and projection to identify the locations of the hot spots in the Galileo image. NASA/JPL

recent "ice volcanism" on Europa where liquid water beneath the ice crust erupted onto the frozen surface. The recent ice volcanism indicates the presence of internal heat, which supports the idea that Europa may indeed have liquid water under its crust.

However, scientists think that most of the initial heat created in the formation of this icy moon dissipated long ago. What then is the source of the stresses acting on Europa's surface and what is the source of its internal heat? The answer lies not within, but beyond Europa: The source is Jupiter itself.

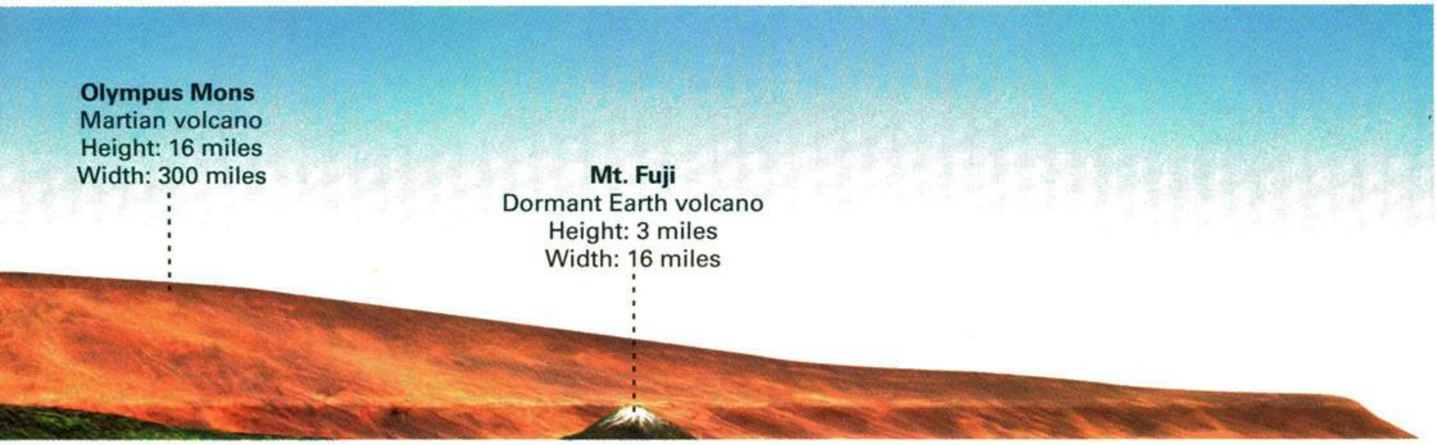
JOVIAN TIDAL FORCES

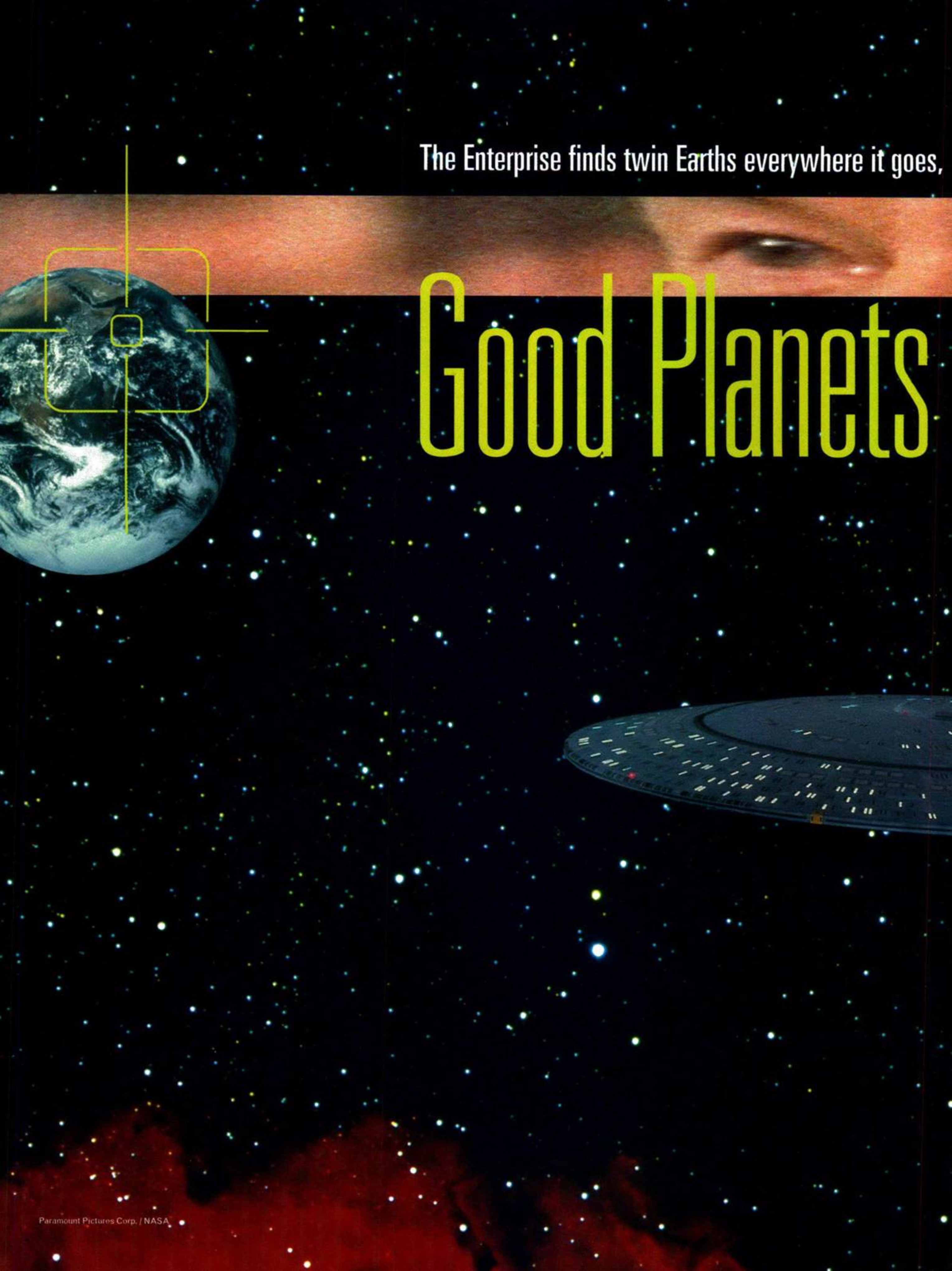
With a mass 300 times that of Earth, Jupiter's immense gravity flexes Europa's crust and heats its interior. These so-called tidal forces also tug on the jovian moon Io, orbiting about 155,000 miles closer to the planet than Europa. The tidal forces generate enough internal heat to sustain volcanic activity on Io. Ganymede orbits Jupiter at almost twice the distance of Europa, so the tidal forces acting upon it are much less.

As remote as the moons of Jupiter may seem from Earth's neighborhood of terrestrial planets, these distant worlds possess geologic features that are both exotic and strikingly familiar. The volcanic and tectonic forces that have shaped and reshaped distant planets and moons also have molded our planet.

Each exploration of a distant world reveals something unexpected and teaches us something new. We gain insight with these efforts not only into the origin and evolution of particular planets and moons, but also all the objects in our solar system, including Earth.

Thomas R. Watters is Senior Scientist of the Center for Earth and Planetary Studies at the Smithsonian Institution's National Air and Space Museum in Washington, D.C., and author of Planets: A Smithsonian Guide.





The Enterprise finds twin Earths everywhere it goes,

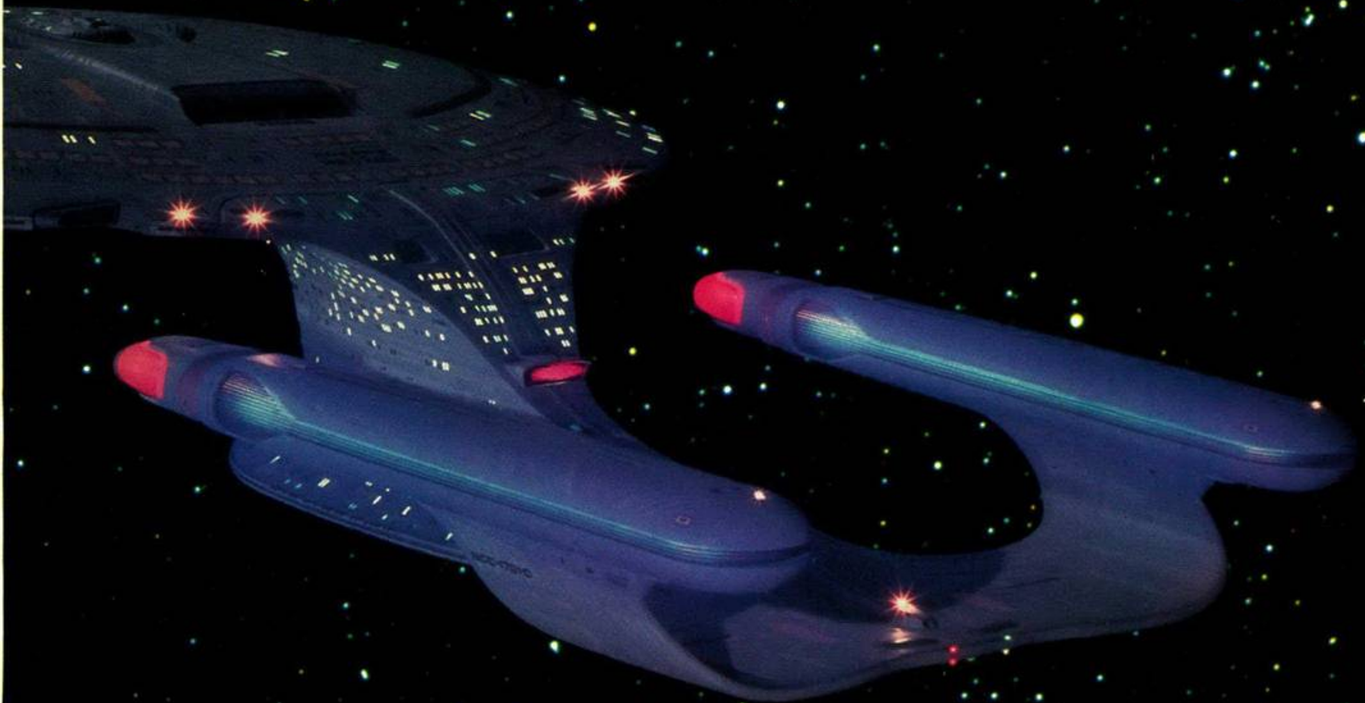
Good Planets

Paramount Pictures Corp. / NASA

but future colonizers of distant planets won't be so lucky.

Are Hard to Find

by Athena Andreadis



HOOKED ON SUREFIRE RECIPES, HOLLYWOOD HAS ALWAYS borrowed heavily from two sources — the Bible, and Greek myths and plays. The latest Star Trek film outing, *Star Trek IX: Insurrection,* scheduled to be released on December 11, follows this hallowed tradition by essentially retelling the expulsion from Eden and the Abel/Cain rivalry. In futuristic terms, *Insurrection* braids together two themes: immortality and planetary colonization.

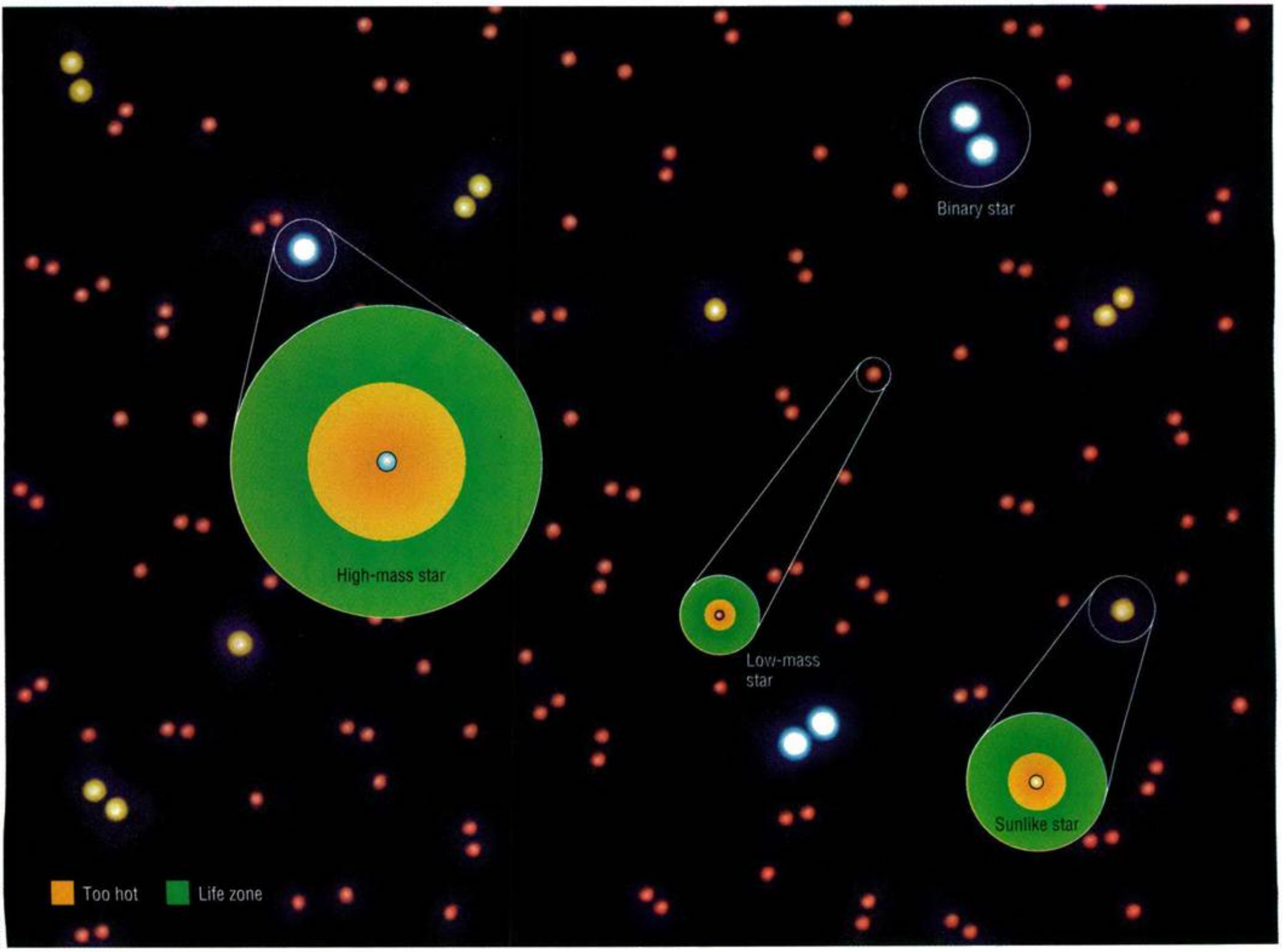
In *Insurrection*, two branches of the same sentient humanoid race have taken the high and low roads to both these endeavors. The Ba'ku, laid-back Southern California types who voluntarily renounced technology, live in an environment that is clearly meant to be Eden before the Fall (and which, as ever in Star Trek, looks like California). As a reward for not having bitten the Apple, the planet's rings conveniently emit "metaphasic radiation" that arrests aging and repairs any damage in the Ba'ku, forcing them into a static social configuration.

The Son'a have gone to the opposite extreme, resorting to regeneration and genetic engineering acrobatics that would turn plastic surgeons green with envy. Expelled from the Ba'ku planetary paradise because they were tempted by the serpent of technology, they have now returned to claim their share of the inheritance by extracting the life-giving radiation from the planet's rings — making the planet uninhabitable in the process. Because the Ba'ku plan to resist passively (a notoriously ineffective ploy), Captain Picard and the crew of the *Enterprise* intervene to save the day. In doing so, they must rebel against Federation brass, who have allied themselves with the Son'a.

Star Trek often mangles its science (in one *Star Trek: Voyager* episode, for instance, a "crack" develops in a black hole's event horizon), but it does use science to pose some fundamental questions; in this case, the fragility and transience of life. Indeed, immortality and colonization of extraterrestrial planets are facets of the same problem: Can we humans flourish if we extend our life significantly, or if we live in a place that is not optimal for us?

Because of fundamental biological construction constraints, we probably cannot do much to lengthen our life span. But colonizing other planets is something we must eventually attempt to survive our sun's evolution, regardless of how well these New Worlds can accommodate us. I'll leave the means of bridging the enormous distances to extrasolar planets to physicists and engineers. What I will delve into is how likely we are to find surrogate Earths to harbor us, and how truly compatible such planets will prove to be.

Only a small minority of stars can support complex life. Low-mass stars (red) have a tiny zone in which a planet could support life. But that zone is so close to the star that the planet will be tidally locked, so only one hemisphere receives sunlight. High-mass stars (blue) have large life zones, but these stars die before life could evolve much. Planets in many binary star systems will have elliptical orbits, leading to extreme climate variations.



Astronomy: Terri Field

Location, Location, Location!

Our Star Trek heroes live in a universe that is excessively endowed with Earth-like planets. Even when shuttles are forced to perform unscheduled emergency landings, they usually manage to crash on planets where neither breathing apparatuses nor protective clothing are necessary, and which often tempt the crew with hanging fruit. But how likely is the existence of the Ba'ku planetary paradise — or of all the other Xerox copies of Earth that have been paraded throughout the rest of Star Trek?

The nature of stars places restrictions on habitable planets. Stars that start their lives with less than half the mass of the sun may have a habitable zone so close to the star that the planet tidally locks, always presenting one face to its primary. The sun-facing hemisphere will be too hot, the other too cold. Stars more than twice the sun's mass probably exhaust their nuclear fuel too quickly to allow life to evolve on habitable planets. Planets in multiple star systems may end up with unstable orbits or orbits that result in extreme climate fluctuations, unless they circle one member of a widely separated double star.

Even with a decent primary star, the list of restrictions goes on and on. A planet at the inner edge of its star's habitable zone may end up with its water vaporized and a runaway greenhouse effect, like Venus. Conversely, a planet at the outer edge of the zone may end up in deep freeze with its water trapped in the crust, like Mars. Jupiter-sized outer planets are probably necessary to deflect comets, whose steady pummeling would prevent emerging life from taking hold. A large satellite may also be required to provide tidal zones, which act as midwives to evolving life. An atmosphere with the right pressure and composition is also a must.

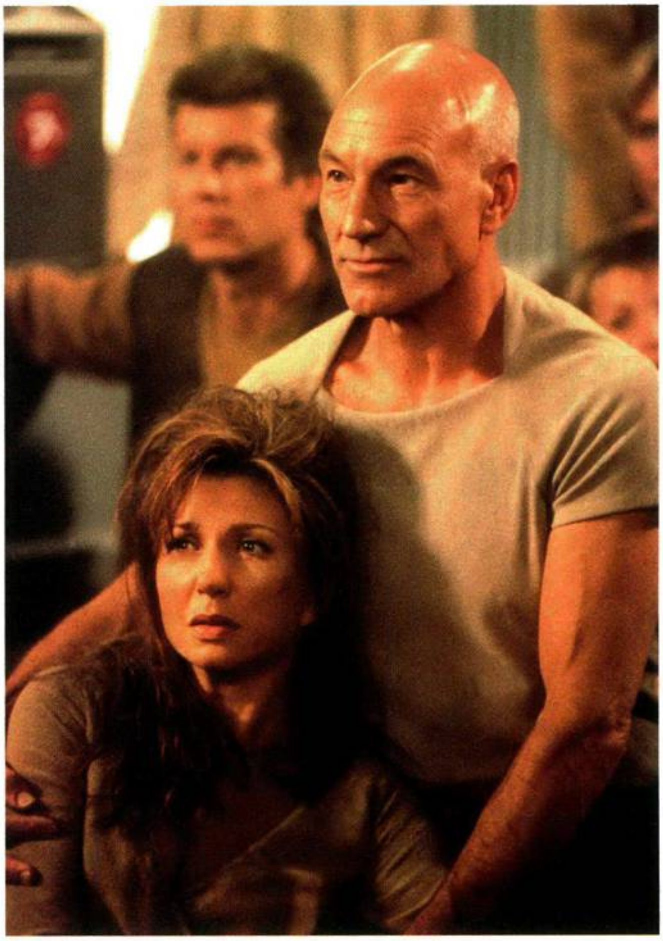
So, contrary to Star Trek's explicit optimism, we're unlikely to ever find a twin Earth. If we find planets within another star's habitable zone, we will probably need to either terraform them extensively or genetically engineer the colonists so that they can survive without external aid — for example, make them able to hibernate.

Either route is so expensive and ethically charged that artificial habitats might be better, though the sad tale of Biosphere 2 is cautionary: The first experiment to create a totally enclosed, self-sufficient environment ended up with oxygen leaks, ecological breakdown, and severe carbon dioxide poisoning — plus virulent infighting among the participants. Fortunately, Biosphere 2 was set up on Earth, where the surroundings could easily come to the rescue.

The Devil's in the Details

But let's suppose that we do find an unspoiled second Earth. Even if it fulfills all the requirements of the long astrophysical/planetological list, details are also important.

For instance, one issue rarely discussed in science fiction is that all molecules involved in life display the property of chirality (Greek for "hand"). That is, they are fundamentally asymmetric. This happens because carbon, the basis for terrestrial life — and the best candidate for life anywhere else — can bond to four other atoms. If all four atoms are different, the resulting compound can adopt one of two mirror-image configurations. Life on Earth has exclusively chosen one of the two possible configurations — the "left-handed" orientation — and has stuck to it throughout its evolution.



Paramount Pictures Corp.

Captain Picard (played by Patrick Stewart) befriends a Ba'ku woman (Donna Murphy). Real extraterrestrials won't look like human beings.

If the biochemistry of New Earth is right-handed, we won't be able to digest any native foodstuffs, because our digestive apparatus will not be able to degrade them into useful units nor use them for energy. No matter how luscious the fruit appears, it will be strictly eye candy. The alternative will be to introduce terrestrial animals and plants, which may overwhelm indigenous life.

Other problems could doom would-be colonizers. Excessive storms, floods, quakes, or volcanic eruptions may disqualify an otherwise lovely planet. Gravity significantly lower than terrestrial will make our muscles atrophy and turn our hip and leg bones brittle. A day of different length will confound our biological rhythms. A primary star of a different color will do the same to our vision. Such dislocations would drastically decrease our ability to survive, because the compatibility of inner and outer cues intimately affects competence and health. And this is only a very partial list.

Contemporary Westerners tend to forget that even Earth presented humans with major survival challenges before the advent of antibiotics, sterile medical procedures, and clean water. Isolated pockets of humanity were lethal to one another before the development of vaccines — witness the effect of European diseases on native Americans and Australians.

Moreover, the more Earth-like a planet is, the more likely it is to hold bacteria and viruses that will decimate us, because we'll act as novel hosts. Consider viruses for example. These parasites weaken their hosts, yet can't afford to kill them altogether. Most viruses initially lethal to humans are actually benign to their true hosts (for example, influenza to pigs and ducks). Though viruses are wizards at rapid change, they will be much harder on new hosts to which they haven't adapted — as is evident from the recent emergence of the Ebola virus, whose symptoms are similar to those caused by radioactive fallout from a nuclear explosion.

Should We Bring Beads and Whiskey?

Even if we find an ideal planet, should we try to colonize it, given the dismal record of human colonization on Earth? Could an Earth-like world such as the Ba'ku planet even evolve intelligent indigenous life? Some prominent scientists believe that self-aware intelligence might be a "fluke" and hence very rare in the universe. They point out that humanity is the only species that became sentient on Earth, even though tens of billions of other species have existed during the planet's 4.6-billion-year history.

I think that is too pessimistic an assessment. The fact that humans stand alone does not preclude non-human sentience, on Earth or elsewhere. Once humans developed intelligence they cut off the possible evolution to sentience of any other terrestrial species, even of close humanoid cousins who were already making the transition to high intelligence. The dice of evolution never fall the same way twice — fortune might have smiled on another branch of the tree of life, given enough time and a different path. If events had occurred just slightly differently on Earth, humans wouldn't have appeared. For example, the impact of the large meteor on the Yucatán Peninsula 65 million years ago, which wiped out the dinosaurs, gave mammals their big chance.

Though humans are unique in the cosmos, intelligence most likely is not. If a planet is enough like Earth to tempt us to settle on it, I think it will be favorable enough to eventually grow its own version of intelligence. This raises a serious ethical dilemma, although this issue has never stopped humans from devastating the homes of other humans.

Homesteading with Cellular Phones

Despite all the obstacles to planetary colonization, let's give *Insurrection* a very long rope, and assume that the *deus ex machina* of metaphasic radiation has repaired any ravages caused by incompatibilities between the Ba'ku and their planet. What would happen to a humanoid colony such as the Ba'ku left on an extrasolar planet without technology? Well, they would not be contemplating the metaphysics inherent in a hummingbird's flight. Even immortals need food and shelter. Living with primitive technology is obviously tenable if difficult, but only if the population is kept low to conserve resources. This requires either borderline starvation to render the women infertile or some form of infanticide, both practiced by some low-tech terrestrial cultures. However, low population leads to inbreeding and lethal recessive traits surface.

Terrestrial examples of isolated settlements illustrate the dangers of insufficient technology and population growth. The medieval Norse settlements on Greenland perished despite their iron technology, and their exhumed skeletons

Star Trek Stars Speak Out

What do you like most about the new movie?

Jonathan Frakes: It's a departure from all the movies that preceded it. It is more romantic, and more lush. It's still a wonderful action-adventure movie, as Star Trek movies have to be. But this one is set in Shangri-la, so there was a lot of outdoor shooting, which we rarely get to do. It has a wonderful comedy peppered through it; it has a different gestalt than any of the other films in the franchise.

Patrick Stewart: It's absolutely classic Star Trek material in that the story deals with issues of justice and the rights of a sentient race when they're being abused and manipulated by another race, and concerns whether any cause is worth sacrificing a single person.

On Earth, the history of exploration and colonization has been a tale of exploitation and violence. Should we explore outer space?

Patrick Stewart: We're still in the process of making a mess of this planet. So when I think of us taking all that we are and all that we have done, and all that we know and all of our ambitions to other worlds, I'm alarmed, because I don't think we've yet acquired the level of maturity in the widest possible sense to do such a thing.

Jonathan Frakes: One of the themes of this film is that the Ba'ku are these people who live in this Shangri-la. And they have chosen philosophically to reject technology. They have warp capabilities and they understand what a positronic matrix is. But the Ba'ku have chosen to reject technology. I wonder if in the future, a group of people somewhere on Earth will choose, after having all these technological advances, to make life simpler.

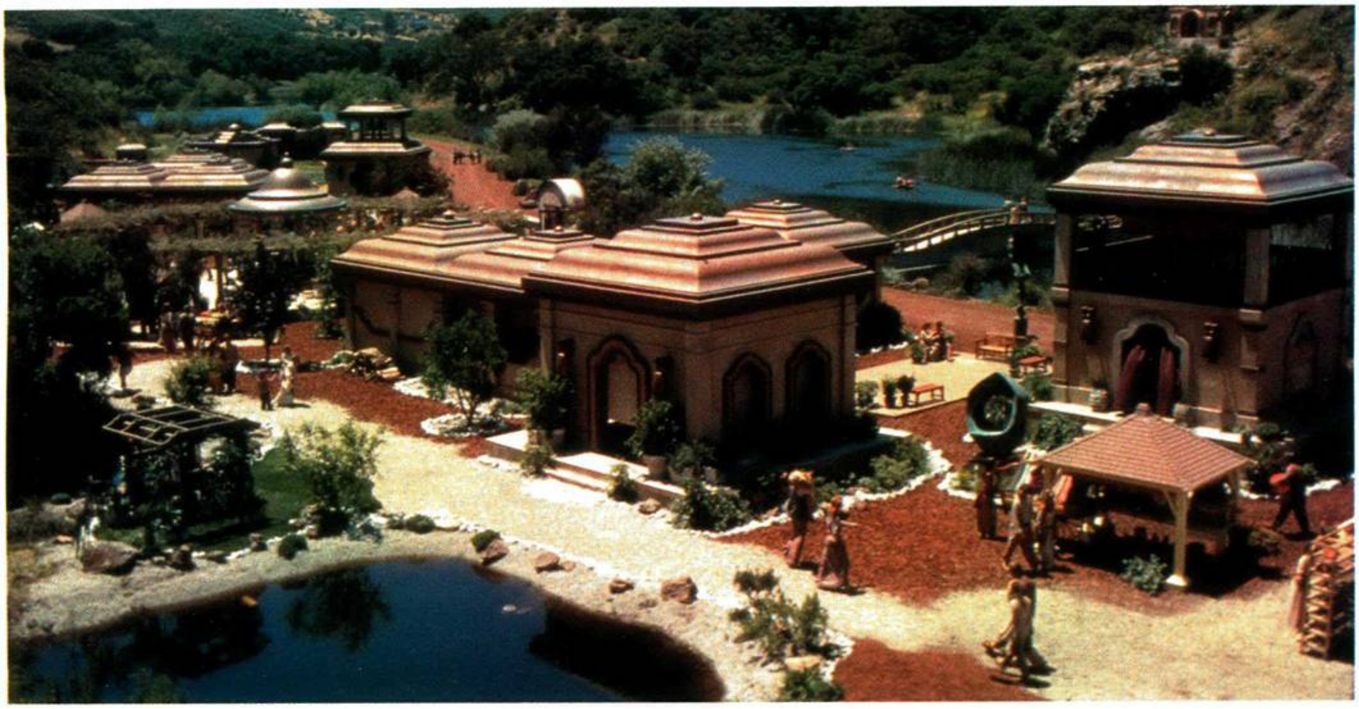
Gates McFadden: I think it will be a lesson that we'll have to learn first on this planet, because we don't seem to have learned it very well. We obviously have to deal with the environmental issues that confront us. And when do we finally all stop working to outdo each other, and when do we start to collaborate and live in unity? I think tolerance is at a very low point in the world right now, which is quite disturbing.

Do you share Star Trek's famous optimistic vision of the future?

Patrick Stewart: I think the future as shown in Star Trek is perhaps a little utopian. I know this was Gene Roddenberry's view, that a world of justice and equality and fairness was something which lay positively in our future. But we're a long, long way from that idyllic world.

Gates McFadden: We actually might be moving further along toward that vision, or we might not be here at all. As individuals we have choices. We can choose things that will go toward that future, or we can make choices that will lead to quicker destruction of the planet and our civilization.

Full-length transcripts of these interviews can be found on our website: http://www.astronomy.com.

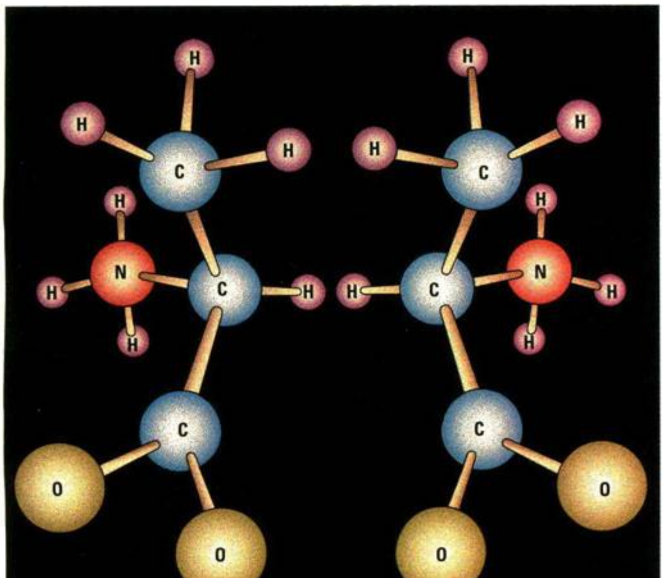


Paramount Pictures Corp.

As is typical of Star Trek, the alien planet in *Insurrection* looks like Southern California. But real alien planets would look, well, alien.

were stunted because the people suffered from malnutrition. The Polynesians of Pitcairn and Easter islands stripped their lush islands of vegetation (including the trees needed to make canoes and catamarans), resorted to cannibalism, and became extinct within a few hundred years of their arrival.

The flip side of this coin is that isolated human colonies may be the springboard for continued speciation of our species, which our increased homogenization has negated. The differentiation of humans into truly separate branches will force us to face our hard-wired fear of anyone who is almost like us, but not quite. The last true such encounter was roughly 40,000 years ago, between the Neanderthals and the Cro-Magnon, though it has been replayed in countless first contact situations between cultures ever since (not to mention the exchanges between the sexes). This xenophobia served us well when we emerged from the African savanna, but now it has become counterproductive. It will be interesting to find out if our brains have expanded on that subject — for true contact with extraterrestrials would require much greater flexibility.



Organic molecules come in "left-handed" (left) and "right-handed" configurations. All terrestrial life is based on the former. But life on another planet might have chosen the latter. Humans couldn't eat "right-handed" food because our digestive system couldn't break down the molecules into useful energy.

Astronomy: Terri Field

At some point, humans will have no choice but to expand beyond Earth. Even if we take infinite care of our finite resources, the sun will eventually enter the red giant phase — and it will have vaporized our oceans long before then. It is easy to say that we should colonize reverently like the Ba'ku, not be pillagers like the Son'a. However, ethics fade when survival is at stake and past human behavior is not reassuring on this point. We, unlike the *Enterprise* crew, will be faced with hard problems and probably even harder solutions.

If we have to alter extrasolar Earth-like planets but have some leeway as to when and how, perhaps our best and most adventurous gambit is to send not humans, but other terrestrial flora and fauna. It is possible that these will generate their own intelligent offshoots and, since their original life code is identical to ours, they may give us true companions in the billions of years left to the universe — and, with luck and care, to us. ◼

Athena Andreadis is assistant professor of neurology at Harvard Medical School and the Eunice Kennedy Shriver Center. She is author of To Seek Out New Life: The Biology of Star Trek *(http://www.toseekoutnewlife.com), published by Crown Publishers, Inc. Her Star Trek favorites are* Deep Space Nine *and* The Wrath of Khan.

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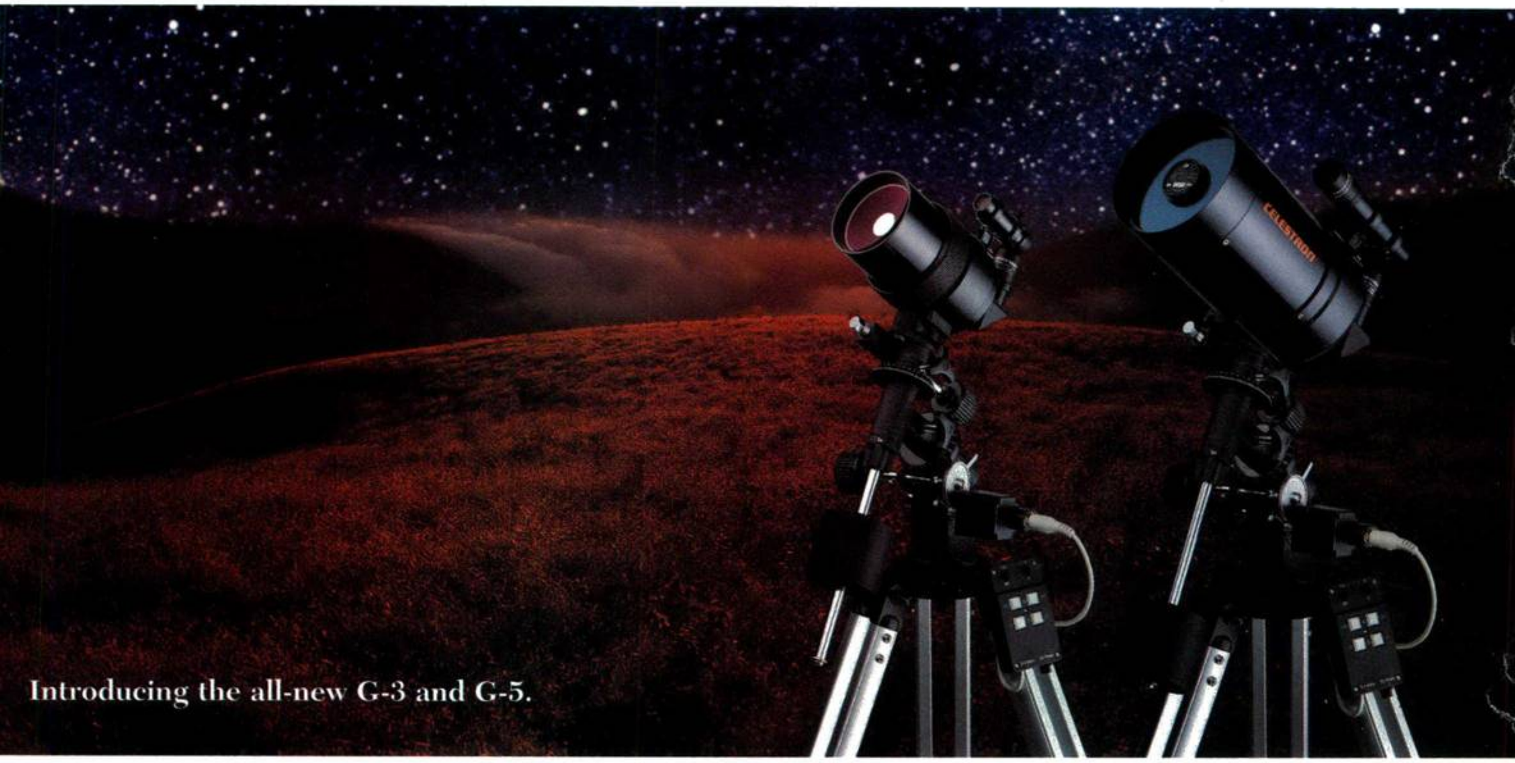

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German Equatorial Mount
Aluminum Tripod & Accessory Tray
Weight: 5.3 lbs = Telescope
  17.3 lbs =Telescope/tripod & mount
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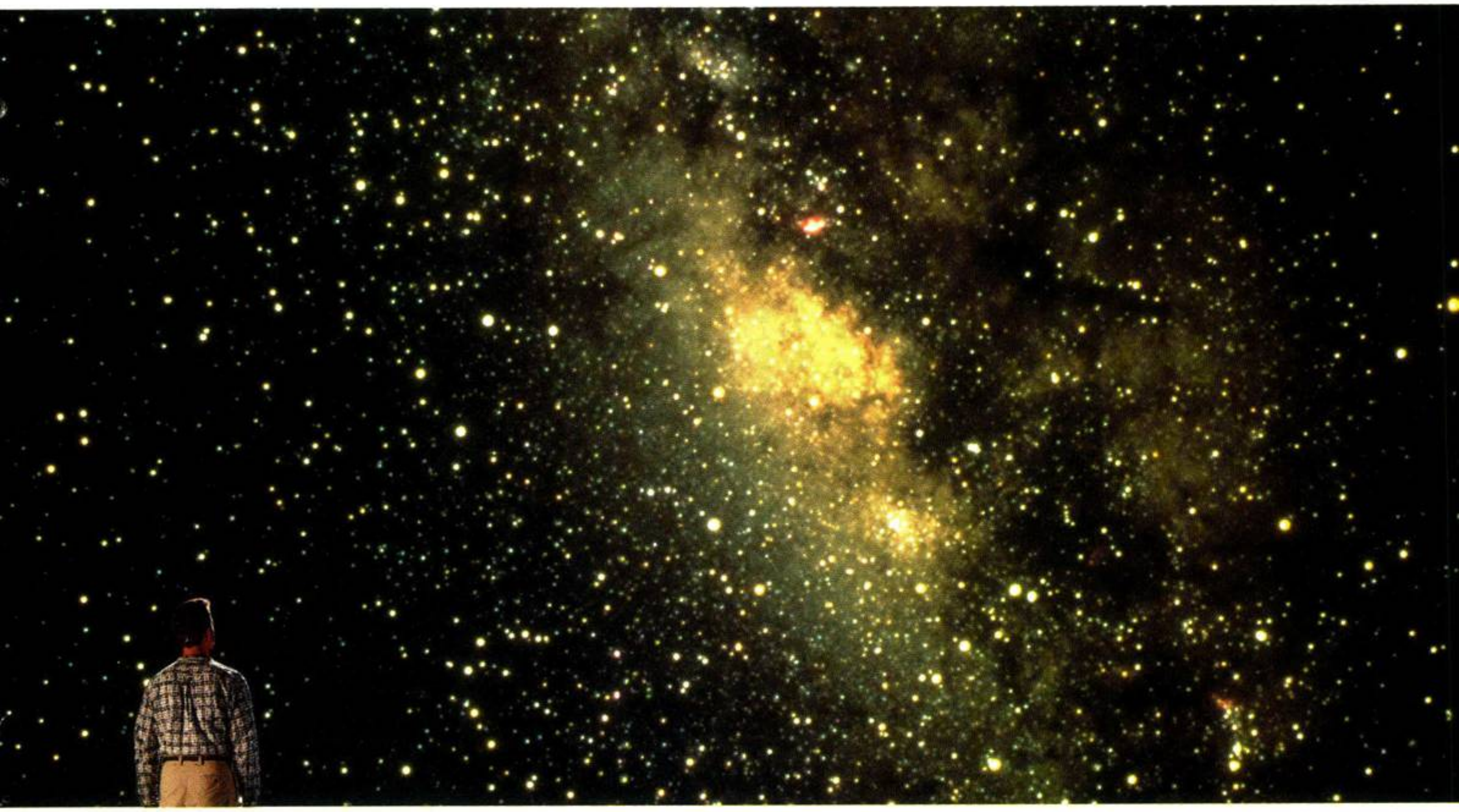
The Universe.



Milky Way photo courtesy of NOAO.

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THE SKY SHOW

The planets reign supreme as Jupiter and Saturn wait for Venus in the evening sky.

by Martin Ratcliffe and Alister Ling

"What is the bright star I see on my way home from work?" This question will undoubtedly be repeated in many offices and homes as **Venus** opens the New Year with an impressive evening appearance.

The planet rounded the far side of the sun last October and will slowly climb higher in the western sky as the weeks pass. Though its brilliance attracts attention, its greatest elongation east will not occur until June. For the time being, the planet shines at magnitude –3.9 in the constellation Capricornus the Sea Goat. It is the brightest object, other than the moon, in the nighttime sky.

As Venus catches Earth in its orbit around the sun, the illuminated phase shrinks from 95 percent this month to 50 percent at the time of greatest eastern elongation. You'll also notice that the size of the planet's disk will increase as the phase shrinks — evidence that it's getting closer to Earth. This month our sister world lies 1.6 astronomical units (149 million miles) from Earth and its disk spans 10". Check Venus weekly through your telescope to follow these changes.

The slow trek of Venus away from the sun's twilight glow takes it past two outer planets that lie in the same direction in space. On January 5, a dim 8th-magnitude **Neptune** lies 1.7° north of Venus. Eight days later, on January 13, Venus lies a mere 0.9° south of **Uranus**. Although Neptune will be too dim to see, you have a chance to spot 6th-magnitude Uranus once the sky has darkened enough — the two planets set 80 minutes after the sun.

One of the finest evening sights in astronomy is a slender crescent moon with Venus. The pair hangs low in the west on the evening of January 18. The 31-hour-old moon lies slightly less than 5° west of Venus for East Coast observers. On the West Coast, the gap will have shrunk to less than 4° by sunset. The moon's daily progression against the background stars takes it 2° south of Jupiter on January 21. Two days later, on January 23, it lies 5° southwest of Saturn.

The full moon rises over the town of Ragusa in Italy. This month brings the opportunity to see two full moons and a rare total penumbral lunar eclipse.

Gianni Tumino

JANUARY 1999

1 Full moon is at 9:49 p.m. EST

3 Earth is at perihelion (91.4 million miles from the sun), 8 a.m. EST

4 Quadrantid meteor shower peaks

5 Venus passes 1.7° south of Neptune, 3 a.m. EST
The moon passes 0.2° north of Regulus, 10 a.m. EST

8 Mars passes 4° north of Spica, 5 p.m. EST (page 78)

9 Last quarter moon is at 9:22 a.m. EST
The moon passes 3° north of Mars, 3 p.m. EST

11 The moon is at apogee (251,550 miles from Earth), 6:42 a.m. EST

13 Venus passes 0.9° south of Uranus, 2 p.m. EST

17 New moon is at 10:46 a.m. EST

19 The moon passes 2° north of Venus, 3 a.m. EST

21 The moon passes 1.8° south of Jupiter, 6 p.m. EST

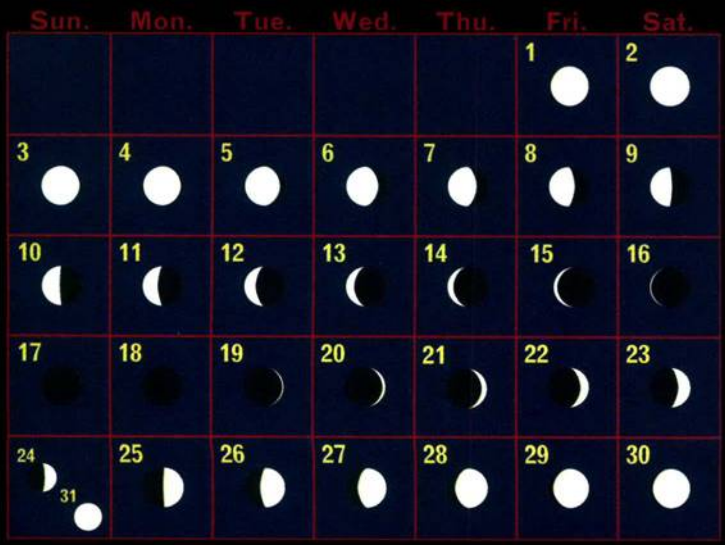
22 Neptune is in conjunction with the sun, 3 a.m. EST

24 The moon passes 2° south of Saturn, 1 a.m. EST
First quarter moon is at 2:15 p.m. EST

26 The moon is at perigee (229,446 miles from Earth), 4:26 p.m. EST

27 The moon passes 0.5° north of Aldebaran, 2 a.m. EST

31 Full moon is at 11:06 a.m. EST; penumbral lunar eclipse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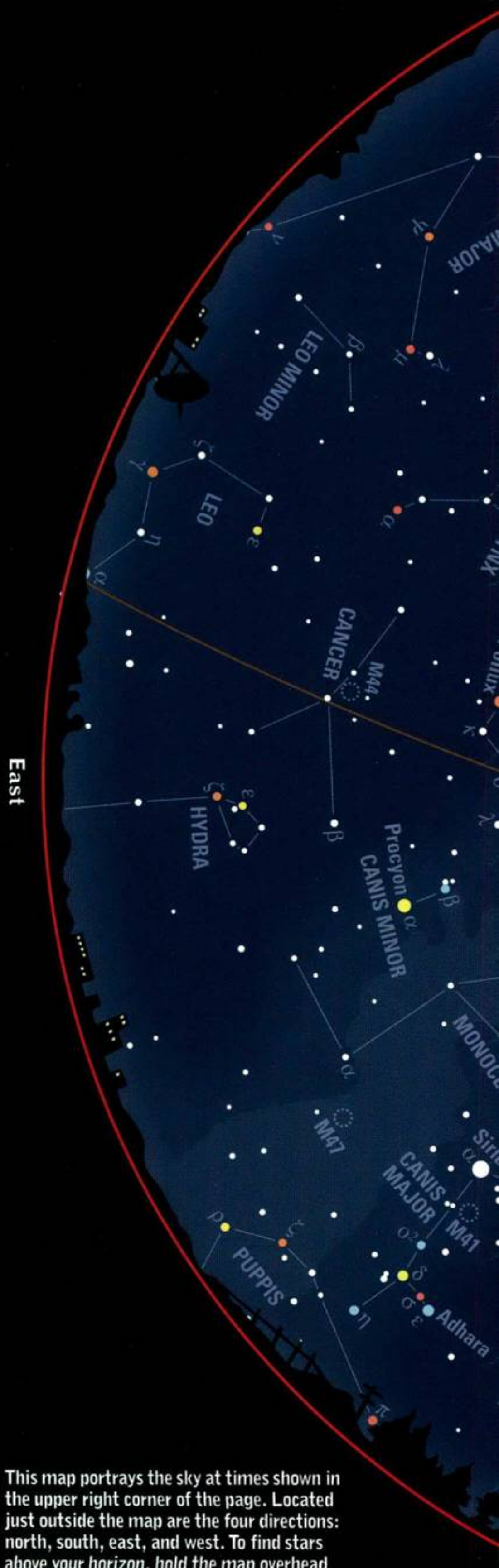
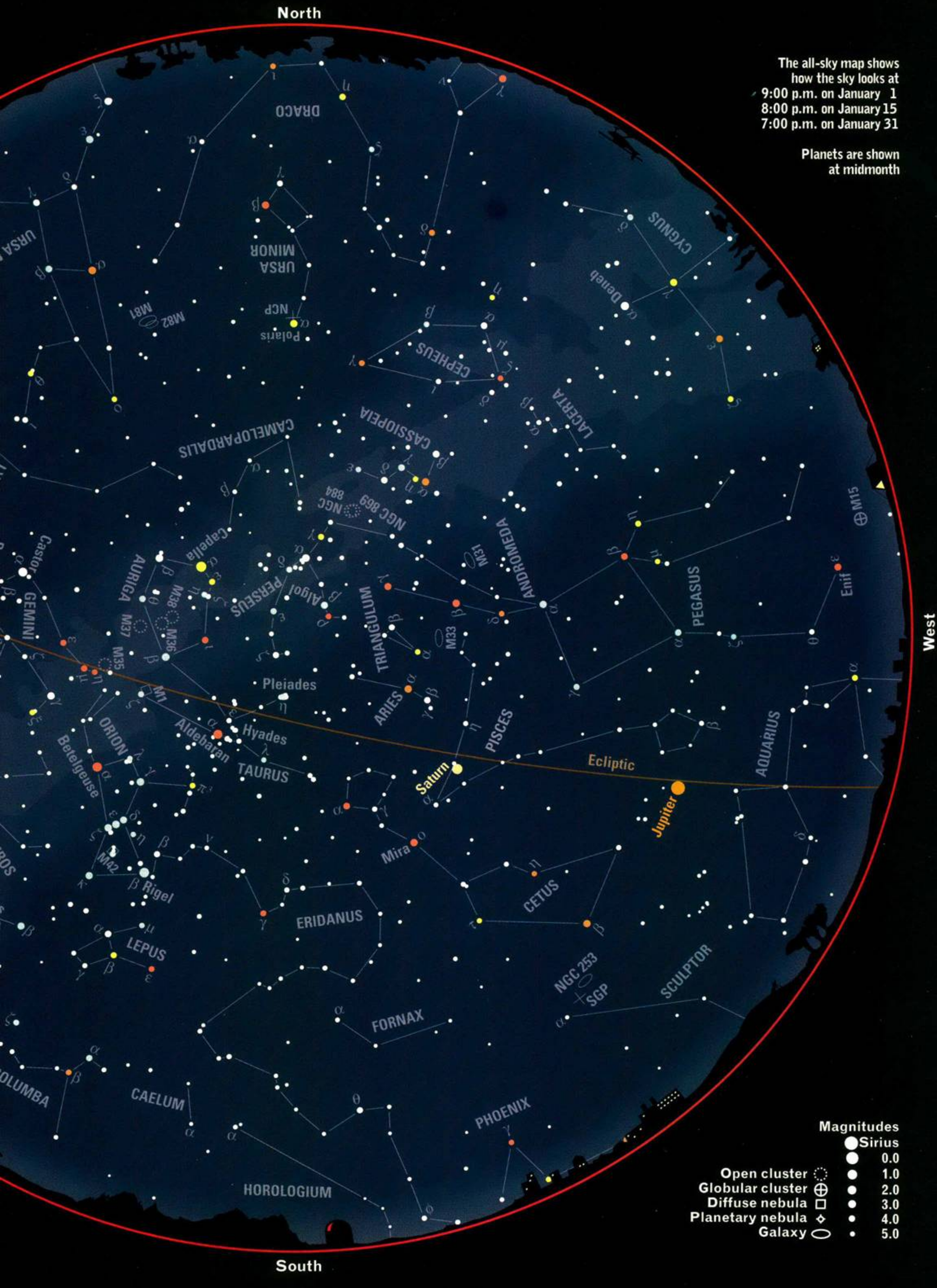

East
MAJOR
LEO MINOR
LEO
NX
CANCER
M44
HYDRA
Procyon
CANIS MINOR
MONOC
M47
CANIS MAJOR
M41
Sir
PUPPIS
Adhara

This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above *your horizon, hold the map* overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows
how the sky looks at
9:00 p.m. on January 1
8:00 p.m. on January 15
7:00 p.m. on January 31

Planets are shown
at midmonth


North
South
West
DRACO
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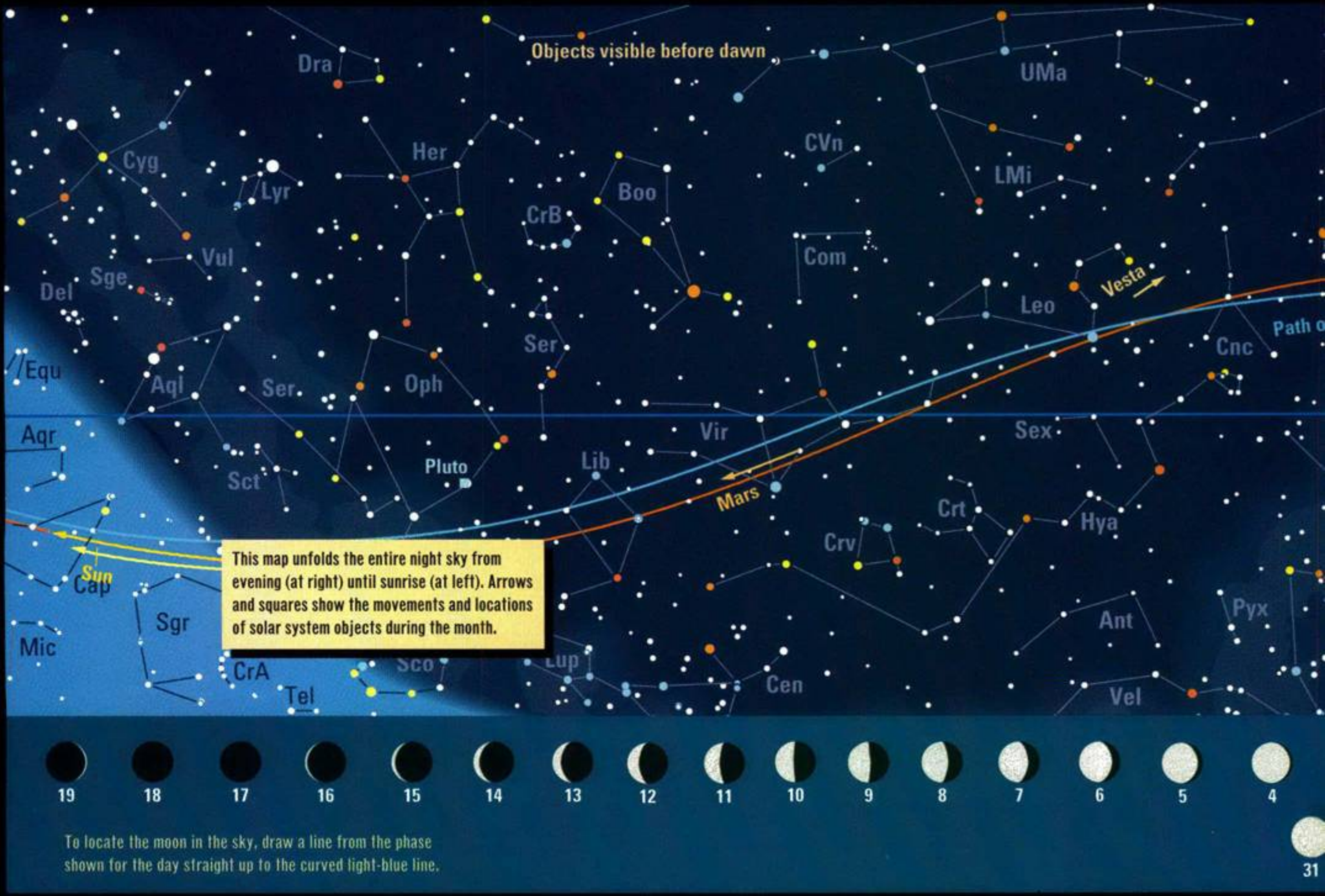
NCP
Polaris
M81
M82
CYGNUS
Deneb
CEPHEUS
LACERTA
CASSIOPEIA
CAMELOPARDALIS
NGC 869
NGC 884
M15
Enif
PEGASUS
ANDROMEDA
M31
M33
TRIANGULUM
PERSEUS
Algol
Capella
AURIGA
M38
M37
M36
M35
GEMINI
Castor
M1
Pleiades
ARIES
PISCES
AQUARIUS
Ecliptic
Saturn
Jupiter
Hyades
Aldebaran
TAURUS
ORION
Betelgeuse
M42
Rigel
Mira
CETUS
ERIDANUS
LEPUS
NGC 253
SGP
SCULPTOR
FORNAX
COLUMBA
CAELUM
PHOENIX
HOROLOGIUM
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS


Objects visible before dawn
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Mars
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Hya
Crv
Sun
Cap
Sgr
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Pyx
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Lup
Cen
Tel
Vel
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4
31

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

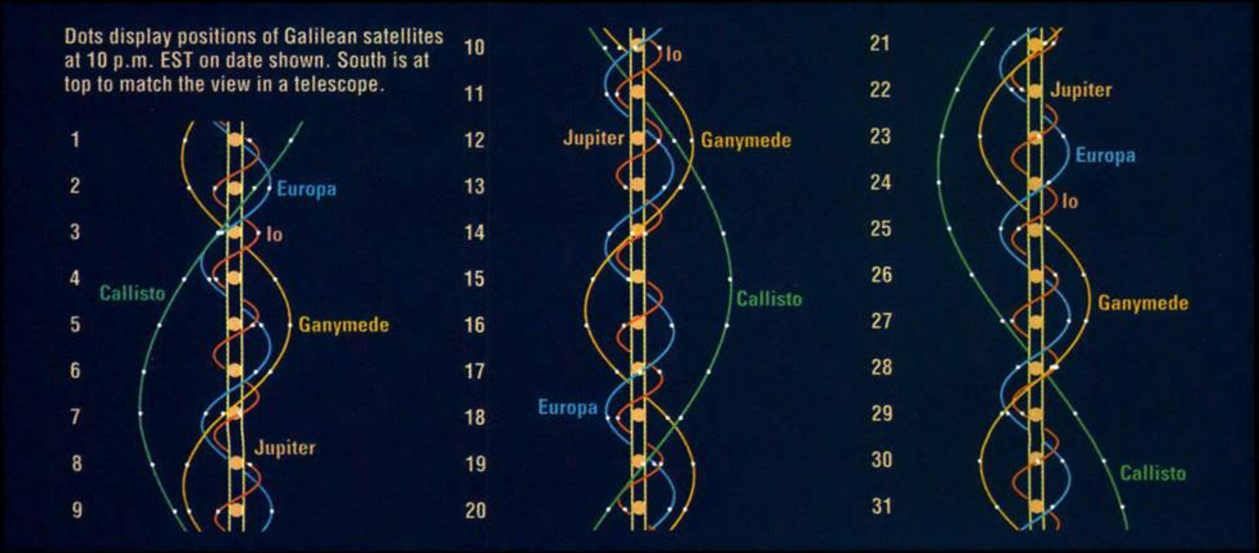
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

10"

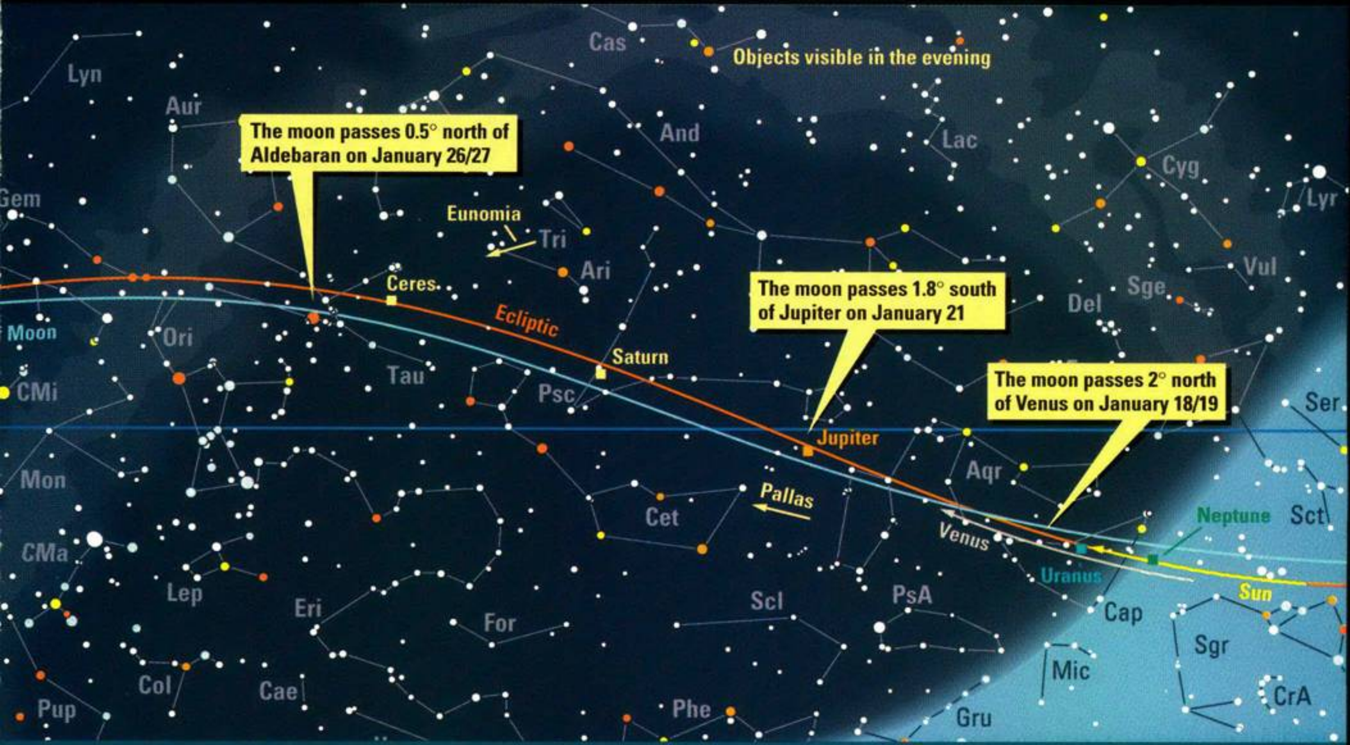
S
W E
N

PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER
Date	January 1	January 15	January 15	January 15	January 15
Magnitude	−0.4	−0.5	−3.9	0.8	−2.2
Angular Size	5.5"	4.9"	10.5"	6.9"	36.7"
Illumination	84%	94%	95%	90%	99%
Distance (AU) from Earth	1.230	1.375	1.589	1.351	5.376
Distance (AU) from Sun	0.436	0.467	0.728	1.662	4.955
Right Ascension (2000.0)	17h22.3m	18h52.3m	21h03.4m	13h35.8m	23h40.7m
Declination (2000.0)	−22°34'	−23°58'	−18°24'	−7°51'	−3°24'

JUPITER'S MOONS



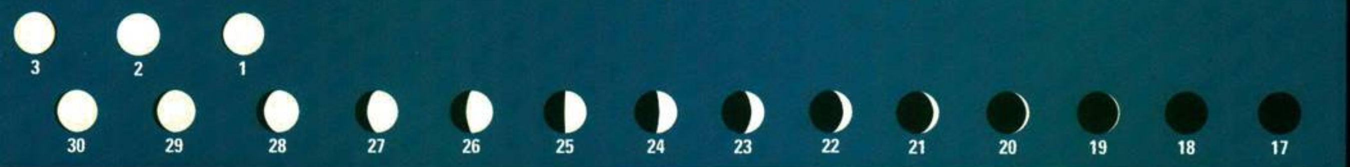
Dots display positions of Galilean satellites at 10 p.m. EST on date shown. South is at top to match the view in a telescope.


Lyn
Aur
Gem
Cas
Objects visible in the evening
And
Lac
Cyg
Lyr
Eunomia
Tri
Ari
Ceres
Vul
Moon
Ori
Ecliptic
Del
Sge
CMi
Tau
Saturn
Psc
Ser
Jupiter
Aqr
Mon
Pallas
Cet
Venus
Neptune
Sct
CMa
Uranus
Sun
Lep
Eri
Scl
PsA
Cap
For
Sgr
Mic
Col
Cae
Phe
CrA
Pup
Gru

The moon passes 0.5° north of Aldebaran on January 26/27

The moon passes 1.8° south of Jupiter on January 21

The moon passes 2° north of Venus on January 18/19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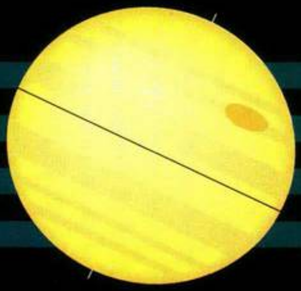
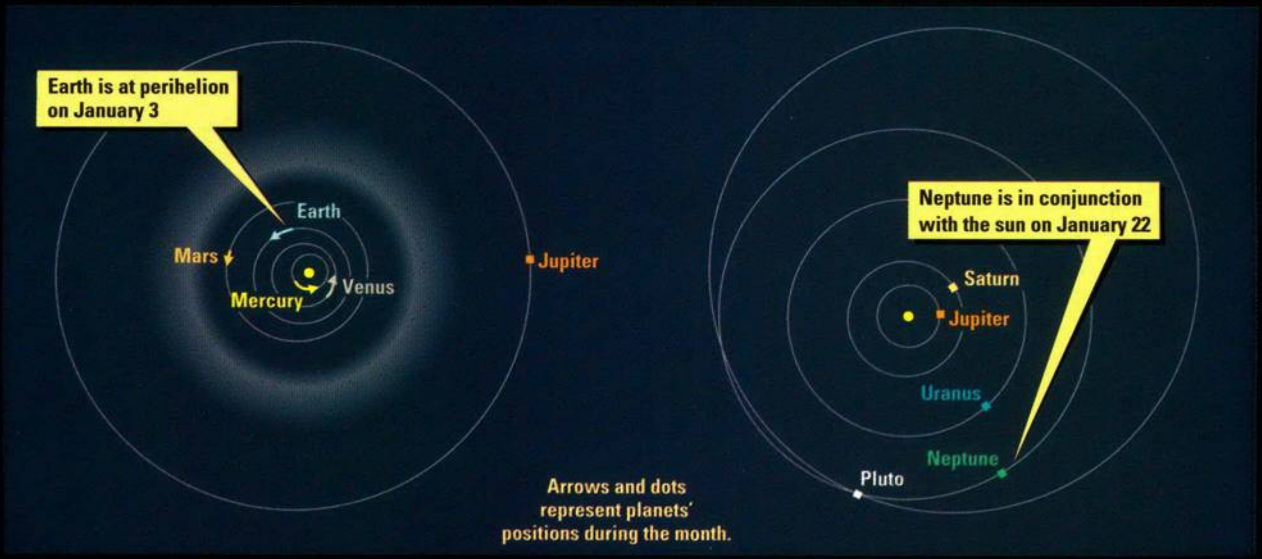


SATURN	URANUS	NEPTUNE	PLUTO
January 15	January 15	January 15	January 15
0.3	5.9	8.0	13.8
18.1"	3.4"	2.2"	0.1"
100%	100%	100%	100%
9.169	20.824	31.108	30.801
9.266	19.888	30.133	30.125
1h43.9m	20h57.5m	20h15.1m	16h38.6m
8°06'	–17°52'	–19°31'	–10°36'

THE PLANETS IN THEIR ORBITS


Earth
Mars
Mercury
Venus
Jupiter
Saturn
Jupiter
Uranus
Neptune
Pluto

Earth is at perihelion on January 3

Neptune is in conjunction with the sun on January 22

Arrows and dots represent planets' positions during the month.

FIRST VIEWS: The Great Winter Circle

Jerry Lodriguss

One of the finest naked-eye sections of the sky lies due south on winter evenings — even non-astronomers have heard the names Sirius, Betelgeuse, Castor, and Pollux. To many of us, these names evoke visions of bright, sparkling stars, one's breath condensing in the air, and snow underfoot.

Have you ever wondered why the stars appear so bright in winter? It's not so much the crisp air — which indeed is cleaner than summertime air — but the stars themselves. The winter sky has a fair number of stars that are either nearby or very luminous supergiants.

Sirius is first. Only 8.6 light-years away, this hot, bluish-white star has a luminosity more than 20 times the sun's.

Moving clockwise from Sirius leads us to yellow Procyon. Only seven times brighter than the sun, if it were much farther away than 11 light-years, it would be too faint to have a proper name.

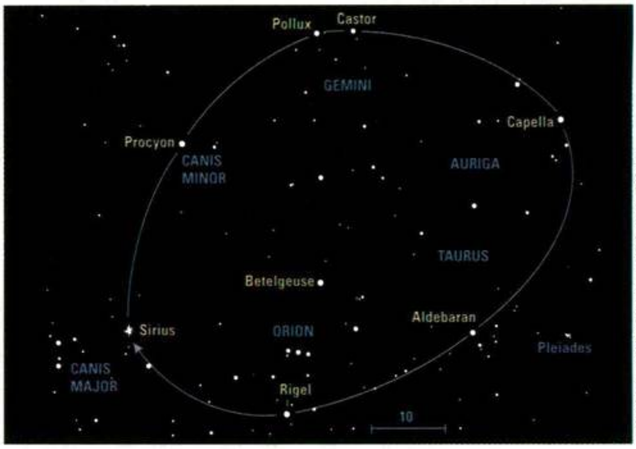
Next up are Castor and Pollux, or is it Pollux and Castor? One easy way to remember which is which: Castor is nearer to Capella and Pollux is nearer to Procyon. Pollux is 34 light-years away, yet its large size allows it to brighten the night sky. The sun would be a 5th-magnitude speck at that distance. And Castor? It's piercing white light is twice as luminous as Sirius. The star's 52 light-year distance makes it appear much dimmer.

Capella is next. At a distance of 42 light-years, this double star casts a distinct yellow color. Together, the pair generates 130 times more light than our sun.

The fiery red eye of the Bull, Aldebaran, is a bloated, red giant. The star is so large that it takes a noticeable amount of time to disappear behind the moon's edge during an occultation.

Rigel's bright blue glow is the last stop before the circle closes. It is 40,000 times brighter than the sun and lies a vast 800 light-years away. If Rigel were as close to Earth as Pollux, it would radiate at magnitude –7.

At the center of the Winter Circle is the red supergiant, Betelgeuse. This biggest star of the bunch is so large that its red disk reveals star spots in professional telescopes — an incredible feat for a star 400 light-years away.



All illustrations by *Astronomy*: Elisabeth Rowan

The first full moon of the year occurs on January 1. The still-bright moon interferes with the Quadrantid meteor shower, which peaks on January 4. The Quandrantids can produce large numbers of meteors during a short period of time. Stalwart meteor observers might catch a handful of some brighter members early in the night.

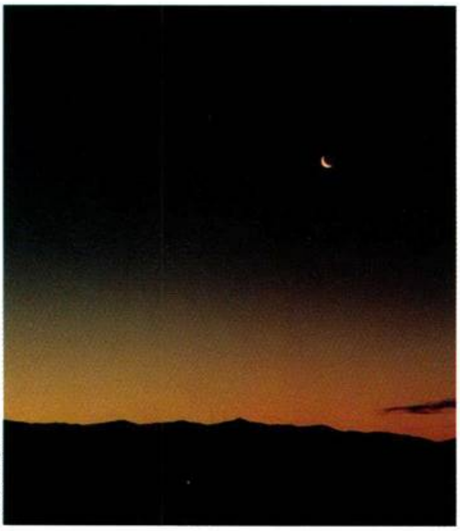
The second full moon of the month is on January 31. When two full moons occur in the same month, the second is referred to as a "blue moon." January's blue moon also undergoes a rather unusual total penumbral eclipse. This means that the moon passes fully into the penumbra of Earth's shadow without entering the darker umbral shadow. This event comes near the time of Earth's perihelion to the sun on January 3 — a time when the umbra is at its smallest and the penumbra is at its largest. Only 1.2 percent of the 10,936 lunar eclipses in 45 centuries are total penumbral eclipses.

The eclipse is visible only from the extreme western portions of the United States and Canada. Islands in the Pacific Ocean, Australia, Asia, eastern Europe, and Africa will also see the event. From San Francisco and other cities on the West Coast, the northern part of the moon will appear noticeably darker just before the moon sets in the early hours of dawn.

Returning to the objects visible earlier in the evening, Venus sets with 1st-magnitude Altair roughly 70 minutes after the sun in early January. By the end of the month, the planet sets roughly 90 minutes after the sun. The bright star Fomalhaut is also setting to the south of Venus. By the time all three have set, the sky is dark and the winter Milky Way can put on its show.

Adjacent to Capricornus is Aquarius. This relatively faint

Crescents, Colors, and Clouds

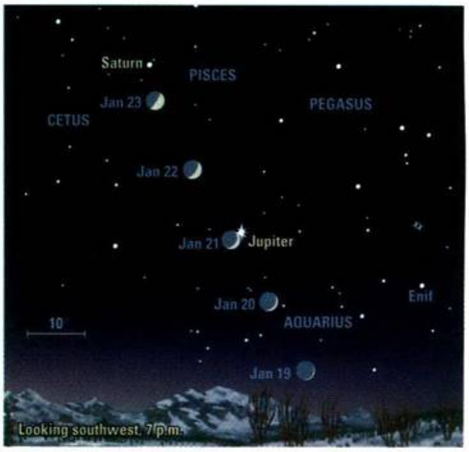

Joshua Vaughn

Thanks to a nice lineup of the moon, Jupiter, and Saturn at midmonth, we can easily compare their brilliant colors. Watch the earthshine-filled crescent moon move away from the veil of the horizon and toward Jupiter on January 19 and 20.

A special opportunity arises on the evening of Thursday, January 21. On that night, Jupiter and the moon set together only 2° apart. Notice that the moon is actually moving to the upper left relative to Jupiter. You can capture this neat effect on film with a simple tripod and a few exposures taken roughly 10 minutes apart. For maximum effect, take these images on the same frame.

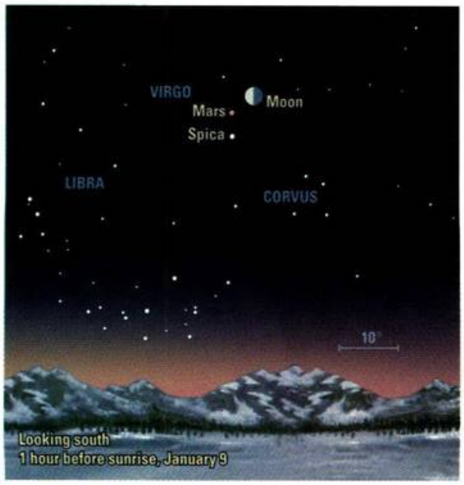
By January 23, the fat crescent lies 6° below Saturn. Use your telescope to magnify all three objects. Compare the warmth of Saturn's gold cloudtops to Jupiter's cooler peach-colored zones. Then stop to look at the moon's stark white landscape.

If you pay attention to Jupiter's limb, you will find that it shows a slight phase — the east limb is not as sharp as the west.



Morning Gathering

In the dead of a northern winter, it is easy to watch the morning solar system action — provided you can come out from under the warm blankets. The sky is just right between 6:30 and 7 a.m. The third quarter moon joins the colorful pair of Mars and Spica high in the south on January 9 and 10.



Mars's magnitude matches Spica's early this month — both shine at magnitude 1.0. Their colors, however, present a nice contrast. Mars has a rusty-orange hue that plays nicely against blue-white Spica. This makes both appear more colorful than they really are. You may want to point a telescope to Mars, but it's tiny 7"-diameter disk will be unimpressive.

The moon barely gets within a binocular field of Mars on January 9 — why not try for a personal record by spotting Mars during the day with binoculars?

constellation is poised in the southwest. Aquarius is depicted as a man pouring water from a jar — the water flows south toward the star Fomalhaut. The Babylonians called this region of the sky "the sea." The region aptly contains such constellations as Cetus the Whale and Pisces the Fish. Both are high in the southwest during the early evenings of January. To the east of these groups, a long line of faint stars runs all the way from Orion, rising majestically in the southeast, down to the southern horizon. This line of stars represents Eridanus the River. Homer called it the "River of Ocean," the body of water suggested to encircle the flat Earth.

The first two weeks of January find the bright planet **Jupiter** in Aquarius. It begins the month at magnitude –2.3 and dominates the fainter stars of this region. As January passes, observers will notice Venus creeping up on Jupiter. By the end of the month, the two planets lie about 23° apart. The twosome are on their way to a spectacular conjunction next month. They will appear together in the evening sky less than ⅙° apart. Jupiter spends the latter half of January in western Pisces fading ever so slightly to magnitude –2.2.

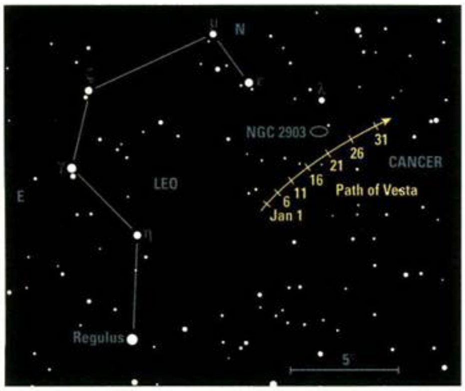
Saturn lingers at the eastern end of Pisces. Somewhat fainter than Jupiter at magnitude 0.3, Saturn is still obviously the brightest object in this area. The southern face of its spectacular ring system is on view to observers with even small telescopes. Saturn's brightest moon, Titan, will also be easily visible at magnitude 8. The large moon takes a little over two weeks to orbit the giant planet. Try tracking its position from night to night.

South of Saturn lies the constellation Cetus the Whale. The famous variable star Mira (Omicron [o] Ceti) is 13°

Vesta Graces the Lion

Vesta is one of the "big four" asteroids, the fourth to be found before a gap of several decades separated them from further discoveries. With a diameter of 300 miles (500 km), 4 Vesta is the third largest asteroid. It reflects a lot of sunlight and comes within easy reach of city-based binocular users. The asteroid's magnitude crests this month at roughly 6.2.

Jack Newton



Vesta is a snap to find. It's just to the west of Leo's Sickle and is currently sliding to the west. Point your binoculars halfway between 8 and 20 Leonis and you're there. Note the pair of 6.5- and 6.8-magnitude stars to the north. They are stationary reference points for finding the slowly moving asteroid.

Deep-sky observers will want to check out the 9.0-magnitude galaxy NGC 2903 on the nights of January 19–25. During that time, Vesta masquerades as an extragalactic supernova 1° from the core of this bright spiral.

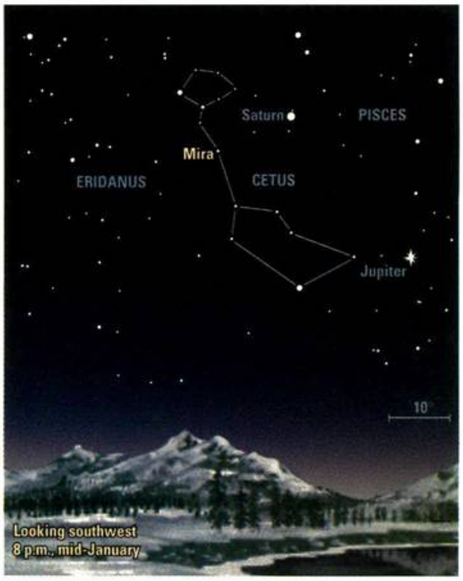
Mira the Wonderful

One intriguing way of watching the universe evolve is to follow the cycle of the star Mira. This large pulsating variable changes its *brightness* with a period that is just short of a year.

Unlike the clockwork of the planets, Mira never keeps perfect time — its irregularity is one of its charms. In fact, the name Mira derives from the Arabic word meaning "the wonderful."

Mira was discovered by David Fabricus in 1596, shortly before the invention of the telescope, and has been followed ever since. Its maximum brightness is typically around magnitude 3.5 but it can get slightly brighter than magnitude 2. After reaching maximum, the star begins a slow decline to 9th magnitude.

One exciting aspect for Mira watchers is that the star's maximum is not predictable. Mira's period fluctuates from year to year. Its cycle varies from less than 310 days to more than 350.

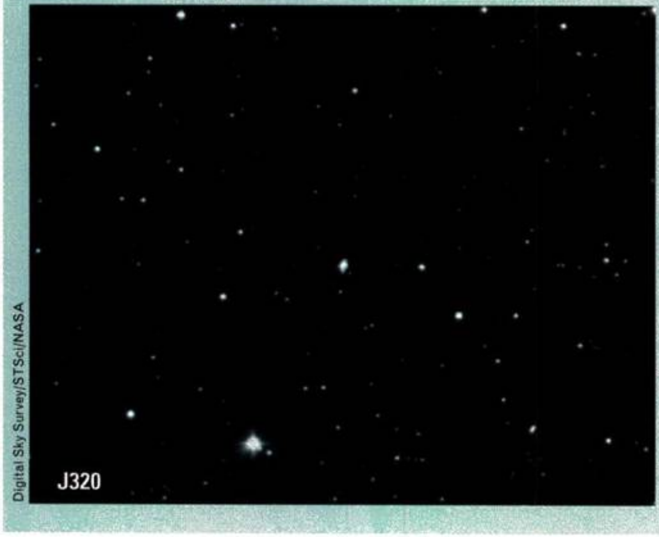


As Mira pulsates, its temperature and color change from a warmer orange to a cooler red. Follow it in a telescope to best see the color.

DEEP-SKY CHALLENGE: Jonckheere's Jewels

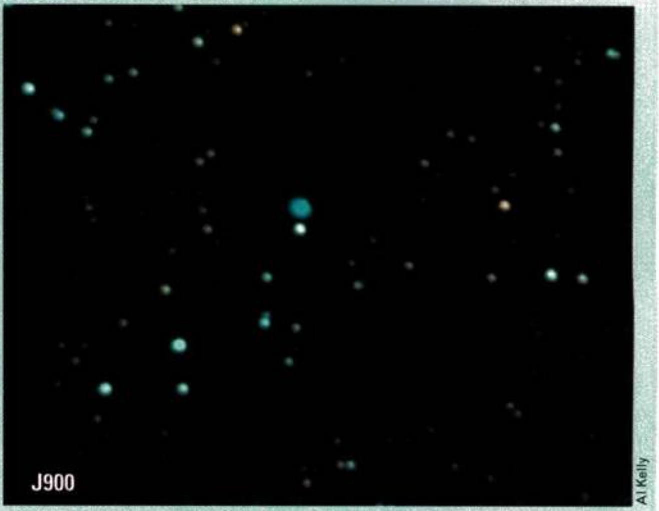
There are many big telescopes that do not deliver the sharp images produced in smaller ones. Large scopes typically are more difficult to keep in optical alignment (collimation), and they are also more susceptible to atmospheric turbulence and tube currents than are medium scopes. A large telescope's main advantage is its light gathering power. To help smaller telescopes even the observing score with the larger ones, let's examine some planetary nebulae that are bright though small.

Joncklieere 320 and 900 were the first two non-NGC objects that I found from city skies. They are visible because of their high surface brightness, which means their light is packed into a tiny area instead of being spread out. Even so, you'll still need at least an 8-inch scope to start the hunt.



Digital Sky Survey/STScI/NASA

J320



J900

Al Kelly

J900 is located at 6h26.0m 17°47' (2000) in Gemini. At 100x with optics that are well aligned, your scope will reveal an 11.8-magnitude fuzzy star. Bump up the power past 200x and the 10" disk will show up. Can you see the slight elongation?

J320 is nearby in Orion, at 5h05.6m 10°42' (2000). At 7" across with a magnitude of 11.9, you'll probably need 150x before you can notice that it is nonstellar.

Just about any star in the field of view may be bloated enough to appear like one of these two small planetaries. A great help in identifying the tiny puff balls is a nebula filter. They work by suppressing the light from normal stars while allowing the nebular light to pass through almost undiminished. The flicker method — simply holding the filter in your fingers and sliding it back and forth between your eye and eyepiece — is the method of choice.

southeast of the planet. This brightest of all long-period variable stars reached its maximum in December 1998 and is now slowly fading. How many weeks can you continue to spot Mira with the naked eye?

The planetary feast of early evening is replaced by the brilliant stars of winter that rise high in the sky by late evening. At 10 p.m. in mid-January Orion stands high in the south. The brilliant contrasting colors of the stars Betelgeuse and Rigel stand at opposite corners of the Hunter's frame.

Sirius and Aldebaran flank the constellation to the southeast and northwest respectively. These stars represent one of the most dramatic sights of the winter sky. Sirius and Aldebaran, along with five other 1st-magnitude stars, form the Great Winter Circle all centered on Betelgeuse.

Turn around and place Orion behind you, to face north. Polaris is the 2nd-magnitude star that is close to the north celestial pole. It also denotes geographical north. For this reason, the star can help those living in the Northern Hemisphere find their latitude above Earth's equator. The altitude of Polaris above the horizon is equivalent to your latitude on Earth. For observers at 40° north latitude, Polaris is 40° above the northern horizon.

To the west of Polaris lies Cepheus the King. Farther west, now sinking toward the horizon, are Pegasus the Winged Horse and Andromeda the Princess. Cassiopeia the Queen lies in the midst of the Milky Way between Andromeda and Cepheus. The Big Dipper can be found to the east of Polaris. This large celestial ladle is beginning to climb high in the sky. When the Big Dipper's parent constellation, Ursa Major, is in this position, you can see the stars of spring rising.

Leo the Lion is clear of the eastern horizon by 10 p.m. The constellation holds a dim solar system object — the minor planet Vesta. Vesta is one of the largest and brightest asteroids. It reaches opposition in early February, but skims about 1° southwest of the 9th-magnitude galaxy NGC 2903 this month. The same meeting happens again on May 22 after Vesta makes its retrograde loop. The asteroid brightens from magnitude 6.9 in early January to 6.2 at the month's end.

While on the topic of asteroids, February should also see the first spacecraft in orbit around one of these rocky minor planets. The Near Earth Asteroid Rendezvous (NEAR) mission is due to begin its orbit around Eros on January 10. After a year-long series of orbital maneuvers, the mission may culminate with a landing on the asteroid in February 2000.

Virgo the Maiden rises above the eastern horizon two hours later than Leo. Climbing with the constellation is the Red Planet, **Mars**. It gains half a magnitude of brightness this month, reaching magnitude 0.5. During this time, the planet also traverses part of Virgo. It comes close to the 4.4-magnitude star Theta (θ) Virginis on January 1, then passes 4° north of Spica on January 8. Mars is slightly brighter than 1.0-magnitude Spica, and its red color creates a stunning contrast with the white star. Joining the pair on their January 8 meeting is the last quarter moon. It can be found just 5° northwest of Mars.

If temptation causes you to point your new Christmas telescope toward the Red Planet, don't be too disappointed. Mars is tiny in any telescope, and this month it spans a mere 7". Instead of despairing, look forward to the next three months. During that time, Mars will more than double its apparent size, making its surface features a little easier to see. The planet ends the month 110.4 million miles from Earth. By the time it reaches opposition on April 24, it will be 53.8 million miles away. For observers in Hawaii and Alaska, Mars occults the 7.1-magnitude star SAO 139407 shortly before 6 a.m. in Alaska and 5 a.m. in Hawaii on January 13. ■

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

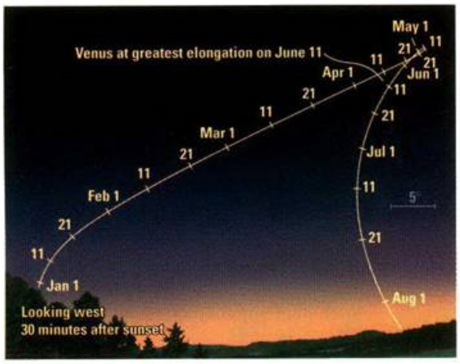
The Evening Star Returns

At long last Venus emerges to adorn the evening sky. As spring approaches, the planet climbs higher and higher in the western sky.

Evening elongations of Venus in spring are the best because the ecliptic is steeply inclined to the horizon. This means Venus will soon stand high in the sky deep into twilight.

Venus began its trek in December. It first scrapes the horizon in bright twilight, some 50 minutes after sunset this month, and this twilight will mask much of its brilliant –3.9 magnitude. By month's end, Venus will be noticed by all the evening commuters heading west after work.

Barry Evans



Our sister planet starts the year at full phase, but has a measly 10" diameter. By the time the dog days of summer roll around, Venus will swell into a majestic crescent phase greater than 40" across.

Mark your calendars for February 17. That date brings a marvelous conjunction of the crescent moon, Venus, and Jupiter. A similar one occurs on March 19 with Saturn taking over Jupiter's role. These two events will offer spectacular photo opportunities.

Orion's Great Nebula

I don't understand people who roll their eyes when they hear the scope is pointed at the Orion Nebula (M42). This fantastic gas cloud is so rich and complex that it's almost impossible to run out of things to see in and around it. Sure you can get tired of a 50x view, but why stop there? M42 is so bright that you can crank the power past 200x and delve into detail.

The first things to look for at higher power are the 5th- and 6th-magnitude stars nestled with the four beacons that form the Trapezium. A fine 6-inch scope on a steady night will reveal the companions. If you picture the two brightest stars as being the top of a cardboard box, then the companions are at the ends of the flaps hanging back down toward the bottom two stars of the box.

My favorite aspect of M42 is the chaotic cloud pattern within the bright central region. There are wisps of brighter material next to short arcs of shadow. The scene is frozen in motion yet so compelling. If there's one reason to have a drive on a telescope, this is it. The only picture of M42's inner region to impress me came from the Hubble Space Telescope. Your eyes can outdo all the others. Take the time to absorb the pastel shades of green. If you're lucky, you may be able to enjoy the purples and pinks.

Jerry Lodriguss

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My
Space
Journal
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USA

Blast off!

Take an imaginative journey into space aboard a rocket you and your child can design and build at home.

by Andrea Gianopoulos

"Ten, nine, eight, seven, six, five, four, three, two, one, LIFTOFF!" The countdown alone makes a child's heart pound with anticipation and excitement. What adventures are waiting?

Rockets provide an ideal way to help children discover the wonders of space exploration. How many among us were inspired by the NASA missions of the 1960s and '70s? I for one spent many evenings standing in my backyard with a flashlight signaling the lunar explorers. Too young to understand that the bright beam wasn't strong enough to make it to the moon, I continued my vigil with the hope that a flash would be returned.

If you have the right vehicle and a vivid imagination, it's an easy jump into space. The first graders of Butte Des Morts Elementary School are a testament to that. Here proud students show off their creations that were made from common household items.

All classroom photos by *Astronomy*: Andrea Gianopoulos/All other photos by *Astronomy*: William Zuback

Try This at Home

Today's children have the space shuttle, orbiting observatories, planetary probes, and a space station to dream of. Though shuttle missions may seem routine to adults, children become enthralled by the process and equipment that delivers astronauts into space. To help foster such interest, try a few simple projects at home. This may include building a model rocket from one of the many kits found in hobby stores, or maybe you would like to try one of the activities outlined on the websites listed in "Rocket Science on the Web." Wonderful Saturday activities like building a rocket car out of plastic foam trays and balloons, making and launching a paper rocket, or building a multistage balloon rocket can be found at the *Space Team Online: Rockets* website. If you're not connected to the web, try the simple and imaginative exercises developed for the first graders of Butte Des Morts Elementary School in Menasha, Wisconsin. They take no special skills and only require the contents of the recycling bin and household junk drawer.

The centerpiece of the Butte Des Morts project was to build a rocket with whatever could be found at home. Cardboard boxes, egg cartons, pie plates, soda bottles, and paper towel tubes became vehicles that traveled to other worlds. Some were painted, while others held colored water. Pom-poms, crayons, silver foil, pipe cleaners, old keys, glitter, packing peanuts, NASA stickers, and bicycle reflectors adorned the more ingenious creations. Each component had a special function. The pipe cleaners served as remote controlled arms that scooped up martian sand for analysis. Silver foil became a nose cone or was used as a protective heat shield to stop the vehicle

My Space Journal!

ROCKET SCIENCE ON THE WEB

The following sites offer students, educators, and parents information and fun activities.

Space Team Online: Home Page
Learn about the men and women who work on NASA's space shuttle and International Space Station. e-mail exchanges and live Web chats allow you to interact with the experts who work on these programs.
http://quest.arc.nasa.gov/space/index.html

Space Team Online: Rockets
An excellent site loaded with activities and rocketry basics. There is even an activity matrix that identifies the standards of learning covered in each activity.
http://quest.arc.nasa.gov/space/teachers/rockets/

The Hitchhikers Guide to Model Rocketry
This site "guides" you through the building process, whether it be your first model rocket or a more advanced home-built design.
http://library.advanced.org/10568/

Model Rocketry for Educators
http://home.earthlink.net/~voraze/toc.html

Johnson Space Center Guide to Astronauts
If you want to become an astronaut, this site can tell you about those selected to the program, the process they went through to be selected, and more.
http://www.jsc.nasa.gov/pao/public/astronauts.html

Teacher's Guide to Rocketry
Learn about the history, scientific principles, and mathematics of rocketry through exciting problem-solving and cooperative learning activities. An Adobe Acrobat Reader is required.
http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Rockets/

FUN FACTS

Did you know Robert H. Goddard is called the "father of modern rocketry?" He experimented with multistage rockets, solid and liquid propellants, developed a system to control flight paths using gyroscopes, and designed payload compartments to house scientific equipment.

The earliest rocket-like device can be traced to ancient Greece and the year 400 B.C. when Archytas of Tarentum built a flying, steam-powered pigeon made of wood.

The space shuttle has four main components: two solid rocket boosters, an external fuel tank, and the orbiter.

It would take roughly 400 thousand subcompact cars to equal the combined thrust made by the space shuttle's two solid rocket boosters, 5.3 million pounds.

The Saturn V rocket's initial stage produced 7.5 million pounds of thrust at liftoff. That's equal to the thrust produced by 566,000 subcompact cars.

If eighteen 6-foot tall humans decided to stand on each other's heads, they would be as tall as the Gemini-Titan rocket — 108 feet. How many people would it take to be 363 feet tall like the Saturn V?

It would take more than 260 cows an entire year to fill the space shuttle's external fuel tank with the 529,000 gallons of milk it would hold.

The shuttle's three main engines produce the same amount of energy as 23 Hoover Dams, more than 46,000 megawatts.

During a shuttle launch, the two solid rocket boosters burn with the orbiter's three main engines for just over two minutes. This gives the shuttle its primary thrust during the first stage of ascent. Once the boosters burn out, they separate and parachute into the ocean. The second stage continues with only the three main engines burning. After nearly nine minutes, the engines turn off and the external tank is jettisoned. It re-enters the atmosphere, where it disintegrates and falls into the Indian or Central Pacific Ocean.

The space shuttle weighs 4.5 million pounds at liftoff, and can carry 65 thousand pounds.

The space shuttle astronauts spice up their meals with packets of mustard, ketchup, mayonnaise, hot sauce, and liquid salt and pepper.

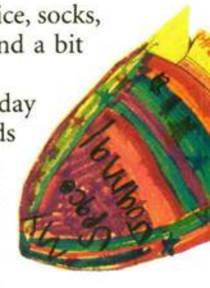
Electricity on the space shuttle is produced by combining hydrogen and oxygen gas. This process also makes water that the astronauts drink.

Space shuttle astronauts use a knife, fork, spoon, and a pair of scissors to eat their meals. The scissors are needed to open the food packets.

The Chinese built gadgets similar to today's rockets in the first century A.D. They filled bamboo sections with a mixture of saltpeter, sulfur, and charcoal dust — a simple gunpowder.

from becoming a cinder on re-entry. The old keys added weight and balance to an otherwise unstable craft. The children thought about the equipment they would need and the function it performed. They each used their own imagination to design and build zversions of the space shuttle, Saturn V, and Sojourner rover.

Each child also kept a five-day space journal. On day one they wrote about themselves, where they were going, what they were bringing along, and how they were feeling about the trip. Adam was headed for Pluto. He brought along a water bottle and lunch for a week. Jordan wanted to visit Mars, but he wouldn't leave without his bed, camera, and a hot dog. Hailey was on her way to Mars as well. She had a space suit, oxygen, bread, water, mustard, turkey, juice, socks, boots, and a helmet with her. Most were excited and a bit frightened, but all were ready to get underway.

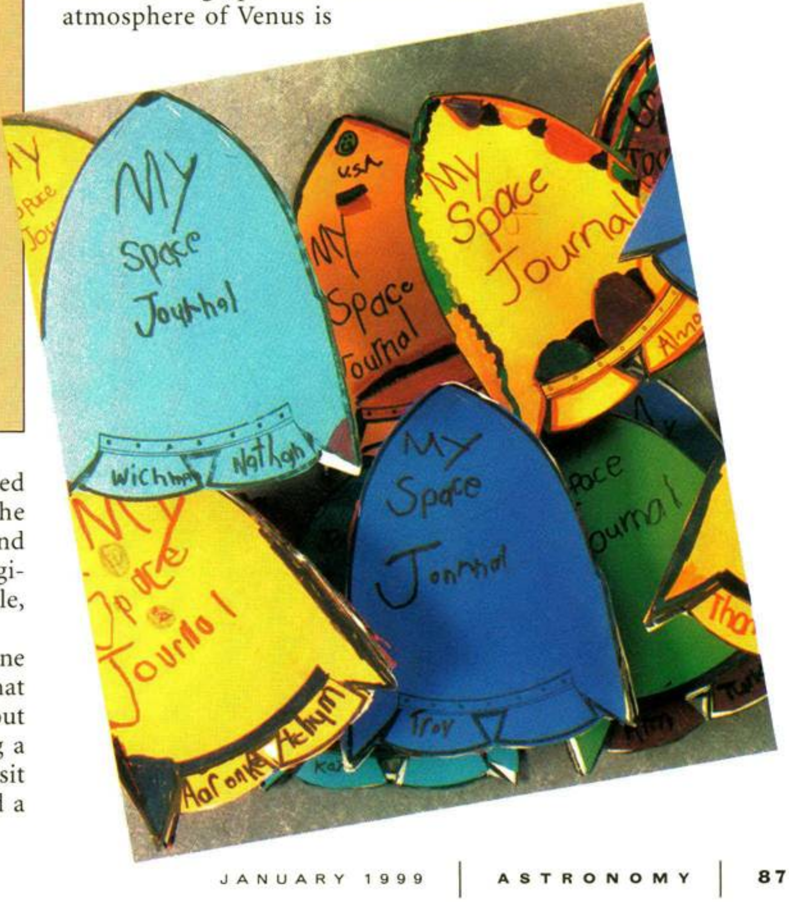


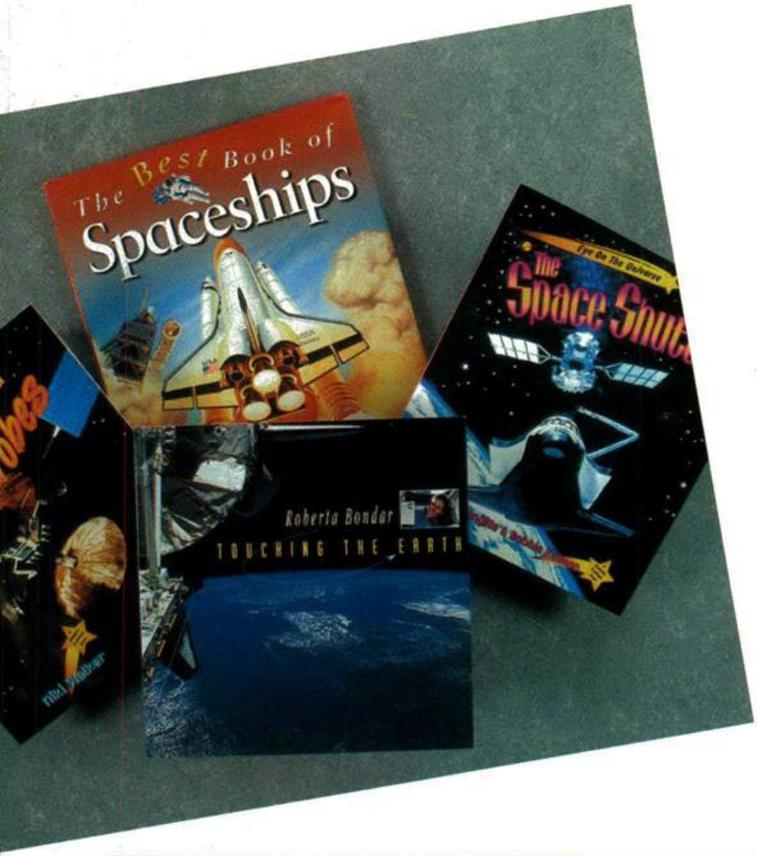
The adventure officially began with liftoff on day two. The children wrote of flying through the clouds and into space, seeing Earth, and being weightless. They saw fire streaming out of the rocket and felt their stomachs rumble with the vibrations. Final destinations were reached on day three and explored through day four. Stephen had journeyed to Jupiter where he collected gases in a soda bottle. Hailey thought Mars smelled like a dump, but found a spotted rock to take home and analyze. Brian not only had to fight the freezing temperatures on Pluto, but the aliens who wanted his spacecraft as well. Meanwhile, Kyle — a good Wisconsin boy — had a hankering for some cheese while he was exploring Mars.

Day five brought these astronauts home. Hailey shared her spotted rock and leftover turkey sandwiches with her family. Brian was rushed to the hospital where he thawed out and healed the wounds from his battle with the aliens.

An exercise like this not only allows your child's imagination to stretch, it also starts a thinking process that teaches through discovery. While dreaming and exploring, the students were also learning.

Another fun project is to study the solar system. Use evening story-time to read books on Mars, Jupiter, Saturn, and their moons. Once you've covered all of the bases, start thinking about what would be required to live on a given world. Any being living on Mercury would have to withstand the radiation from the sun, whereas a house on Pluto would need an excellent furnace and a good source of electric light. A Venusian would feel like she was living in a shallow bowl. The high pressure carbon dioxide atmosphere of Venus is





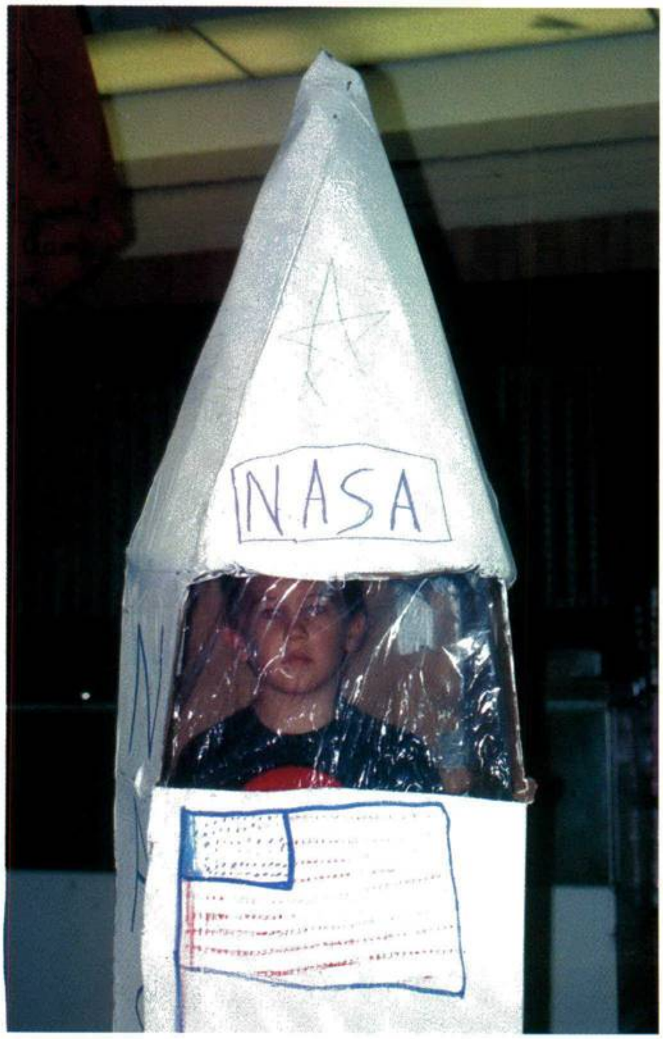
ON THE SHELF

The Best Book of Spaceships
by Ian Graham $10.95
Learn about rockets, satellites, landers, and more.
Reading level: elementary.
Larousse Kingfisher Chambers
95 Madison Avenue, New York, NY 10016

Eye on The Universe: Satellites and Space Probes
by Niki Walker $5.95
This book introduces children to the basic types of satellites, the mechanics of launching them into space, and the history and accomplishments of specific spacecraft.
Reading level: elementary.
Crabtree Publishing Company
350 Fifth Avenue Suite 3308, New York, NY 10118

Eye on The Universe: The Space Shuttle
by Jaqueline Langille and Bobbie Kalman $5.95
The book describes the construction and operation of NASA's space shuttles. It covers such topics as preparation for liftoff, living in space, landing, and mission control.
Reading level: elementary.
Crabtree Publishing Company

Touching the Earth
by Roberta Bondar $19.95
As a youngster, Roberta Bondar built model rockets. Today she is a neurologist and was the first Canadian woman to travel in space. In *Touching the Earth*, Bondar takes readers on her space shuttle journey. She shares her thoughts, experiences, and her love for this blue planet we call home.
Reading level: late elementary/middle school.
Key Porter Books Limited
70 The Esplanade, Toronto, Ontario, Canada M5E 1R2



Brian is ready for liftoff in this home-built version of a Saturn V. His journey took him to Pluto where he fought the cold and evil aliens. Once the journey was over, Brian insisted on taking his rocket home on the school bus.

so dense that the surface appears to curve upwards in all directions. Try developing your own alien life-forms. Beings living on Jupiter's moon Io might live in volcanoes and eat sulfur. Martians might be able to breath dust and use the iron oxides that permeate the landscape.

The Butte Des Morts children did a similar exercise. They worked in teams, each picking a favorite planet to report on. Team Saturn liked the fact that the planet would float, if you could find an ocean large enough to put it in.

These simple activities offer an effective method of teaching through playful discovery. With imagination and a few basic facts supplied by an adult, a child can plan a journey to any place in the universe. ■

The Kid Connection

Send your artwork, poems, riddles, and questions to Kids' Corner, *Astronomy* magazine, P.O. Box 1612, Waukesha, WI 53187-1612, or e-mail kids@astronomy.com.

Test your knowledge with *Astronomy's* online quiz at http://www.astronomy.com.

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Testing the Smoothest Scope in Town

MAG 1 Instruments' Portaball packs the light-gathering power of an 8-inch mirror into an easy-to-use Dobsonian mount built around a spherical base.

by Tom Polakis

Everyone wants an 8-inch telescope, it seems. Falling in as a standard size in the 1970s with the introduction of commercially produced Schmidt-Cassegrains, the 8-inch scope has become the workhorse of the backyard astronomy scene. Its mirror is large enough to show thousands of faint deep-sky objects in reasonably pleasing detail, and the physical stature of the scope itself is small enough to remain portable. With the explosion of 8-inch models offered by the giants of the industry, then, how does a little guy compete?

Veteran telescope maker Peter Smitka of New Berlin, Wisconsin, may have hit on the answer — offer something that's radically different, fun to use, and built around a modified Dobsonian mount concept. Although Smitka runs basically a one-man operation, his result is the 8-inch Portaball, one of the most user-friendly scopes on the market.

The Portaball consists of a base holder, a tube constructed of a sphere that rests inside the base, and metal struts that connect the primary mirror cell with the secondary mirror cell — all put together with elegant, high-grade hardware. The scope is moved around the sky like a conventional Dobsonian, by nudging here and there, but the smooth motion of the ball resting inside its holder makes for a velvety feel and convenient touch. The conventional Dobsonian design is not without its problems. It moves so clumsily through the zenith that some Dob owners avoid this most desirable part of the sky altogether. Dobsonians are not inherently compact, often consuming lots of valuable trunk space.

Photos by Jim Forbes

MAR.I
8" f/6

And eyepiece height is a compromise. Near the horizon, you're kneeling in the dirt while high-altitude viewing requires a crouch. Replacing two bearings with one omnidirectional sphere, the 8-inch Portaball provides an elegant design that is both compact and a joy to use.

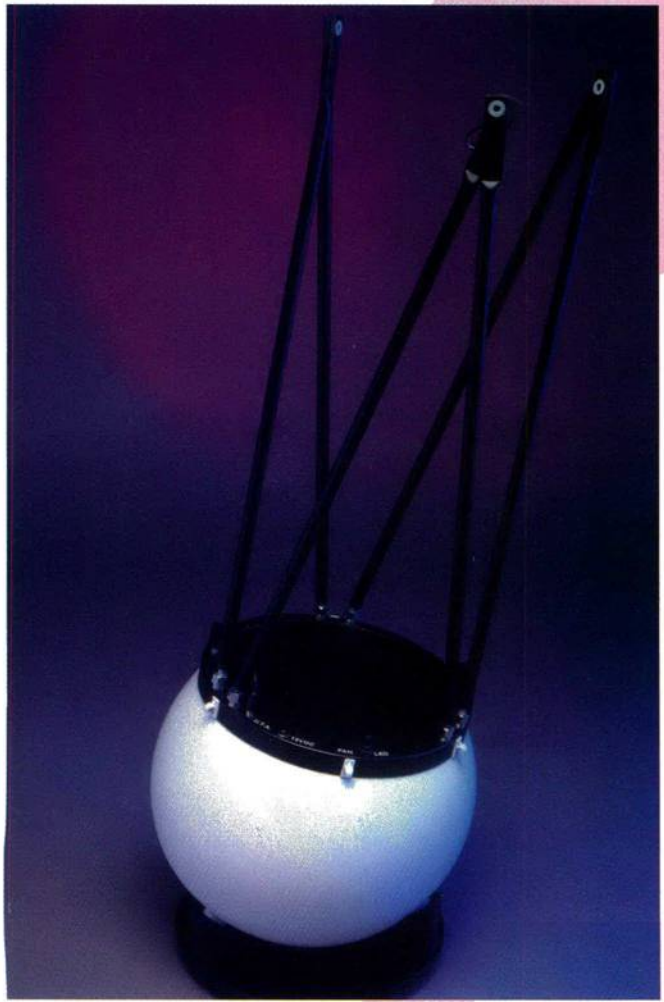
The ball-bearing design is not a new one. It has been sold by Edmund Scientific since 1977 as the venerable 4¼-inch Astroscan. Since then, however, this design has not been developed in the consumer market for larger apertures. In 1993, MAG 1 Instruments introduced the 12½-inch Portaball (see *Astronomy*, March 1995). Now an 8-inch model is available. Its compact size and ease of setup make it ideal for those who desire a moderate-aperture scope but have little room to spare.

Setting Up

The Portaball arrived well packed in two small boxes containing the accessories and one strange looking drum 19 inches in diameter and 22 inches high. This drum housed the telescope. Inside the drum I found the base, upper tube assembly, and sphere, which was packed in an inflated inner tube. This was an early introduction to the fragility of this surface.

Even before setting up the telescope, the fine workmanship became apparent. The attention-grabbing sphere employs fiberglass construction, buffed to a very smooth finish that is key to the telescope's flowing movements. The sphere is a three-segment form, but you'd be hard pressed to find any seams in the surface. Inside the sphere is a layer of glass cloth that acts as an excellent non-reflective surface and the heart of the telescope — an 8-inch f/6 mirror produced by the Zambuto Optical Company.

The Portaball's strong aluminum poles allow the telescope to be set up quickly and give it an elegant feel out under the stars.



The mirror came with an extensive data sheet that documents its individual performance. Weighing in at less than two pounds is the upper tube assembly, which fits compactly into the sphere for transport. The 1.52-inch secondary in this assembly obstructs less than 20 percent of the aperture. For transport, a PVC tube contains the six aluminum truss members that connect the upper tube assembly to the sphere. The sphere rides smoothly on three Teflon bearings mounted to a wooden base. Overall, the first impression out of the box was that there were no rough edges, no cardboard to chip, and no components to forget before that long trip to the site.

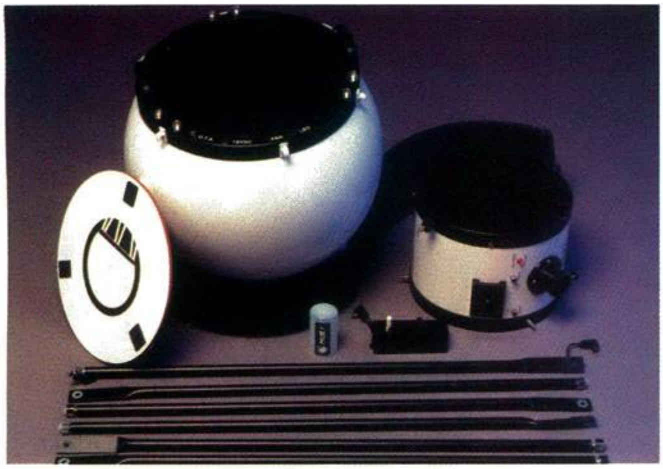
Reading the user-friendly manual, I set the telescope up on the first attempt in 15 minutes. The usual complication associated with truss designs comes with attaching the truss poles and upper cage. The six aluminum poles attached quickly to the sphere without tools by hand tightening threaded fittings that surround ball-and-socket joints. These joints made aligning the three pairs of poles for upper tube installation a snap. The upper tube assembly attached with threaded knobs that are tethered for those who are prone to dropping such items in the field.

Setup was now almost complete, but a truss-tube telescope requires collimation before each use. For this task, a collimating tool is provided that acts in concert with the centrally marked secondary and primary mirrors. Collimation should be simple using the process described in the manual if not for a weak link, the secondary support. The Novak unit provided with the test unit hid one adjusting screw almost inaccessibly behind a spider vane while another was difficult to turn without twisting the secondary. A scope of this caliber would benefit greatly from a higher quality secondary mirror support and, indeed, Smitka has begun working on one of his own design. After laboring through the secondary adjustment, the primary was handily aligned with three knobs that are accessed by simply reaching into the sphere. Those with long arms will be able to align the primary mirror while watching the results in real time through the focuser. Collimating was explained well in the manual, but a few simple illustrations would ease the process for first-time Newtonian owners. After the initial gross adjustments, the scope went together repeatedly in future setups, needing only small tweaks to the collimation.

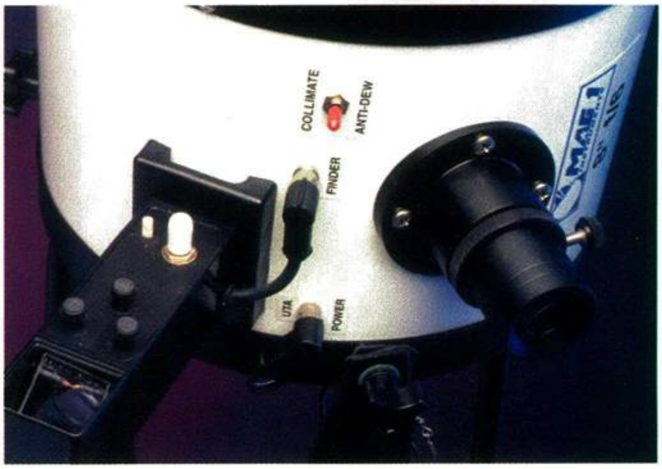
The final step in setting up the Portaball was attaching the finder scope, also designed and manufactured by MAG 1 Instruments. This is a one-power sighting device that projects a red circle on the sky. With a 1½° field of view available through the telescope at low power, the 1x device is adequate for finding most of the brighter astronomical targets.

Mechanical Pros and Cons

I brought the assembled scope out to the backyard for a quick mechanical evaluation. Motions were smooth. Pushing it with only a couple fingers, the scope easily traversed large swaths of sky. It didn't take long to discover that the spherical bearing provides a simple answer to the rotating tube.



Simplicity characterizes the Portaball's design philosophy. Less than a dozen parts comprise the scope, including primary accessories.



The Portaball's business end features a 1x finder scope and a helical focuser; an electrical package provides help with dew and collimation.

This is a sit-down scope in which the eyepiece is always at a comfortable height. I was able to make the eyepiece height adjustment by twisting the tube without losing an object at 100x. Vibrations damped out in a few seconds — typical for a telescope of this aperture. Tracking an object's rising or setting at high power required only a light touch. I followed objects at 250x more effortlessly with the Portaball than with a smooth Dobsonian.

But a radical design such as the Portaball cannot come into being without immanent problems that compromise its elegance. Perhaps more than 20 years of training with two-axis telescopes have corrupted me, but I found it difficult to grow accustomed to unrepeatable, drunken sweeps in searching for targets. This is not a telescope for comet hunters! The telescope often did not stay put while removing the eyepiece, and recapturing the object was no longer achieved with a nudge in altitude or azimuth. To its credit, this is a telescope that stays out of the way of your knees and is not often bumped.

A lesser concern with the spherical bearing is that it does not lend itself to modern accessories such as digital setting circles and two-axis stepper motor drives. However, the entire instrument can be driven using a small Poncet platform. The sphere is a fragile surface, and is prone to dents and dings. Users must be especially aware of such obstacles as door frames when transporting the telescope. The surface can rest only on the Teflon bearings in its wood base or on a soft, cushioned surface.

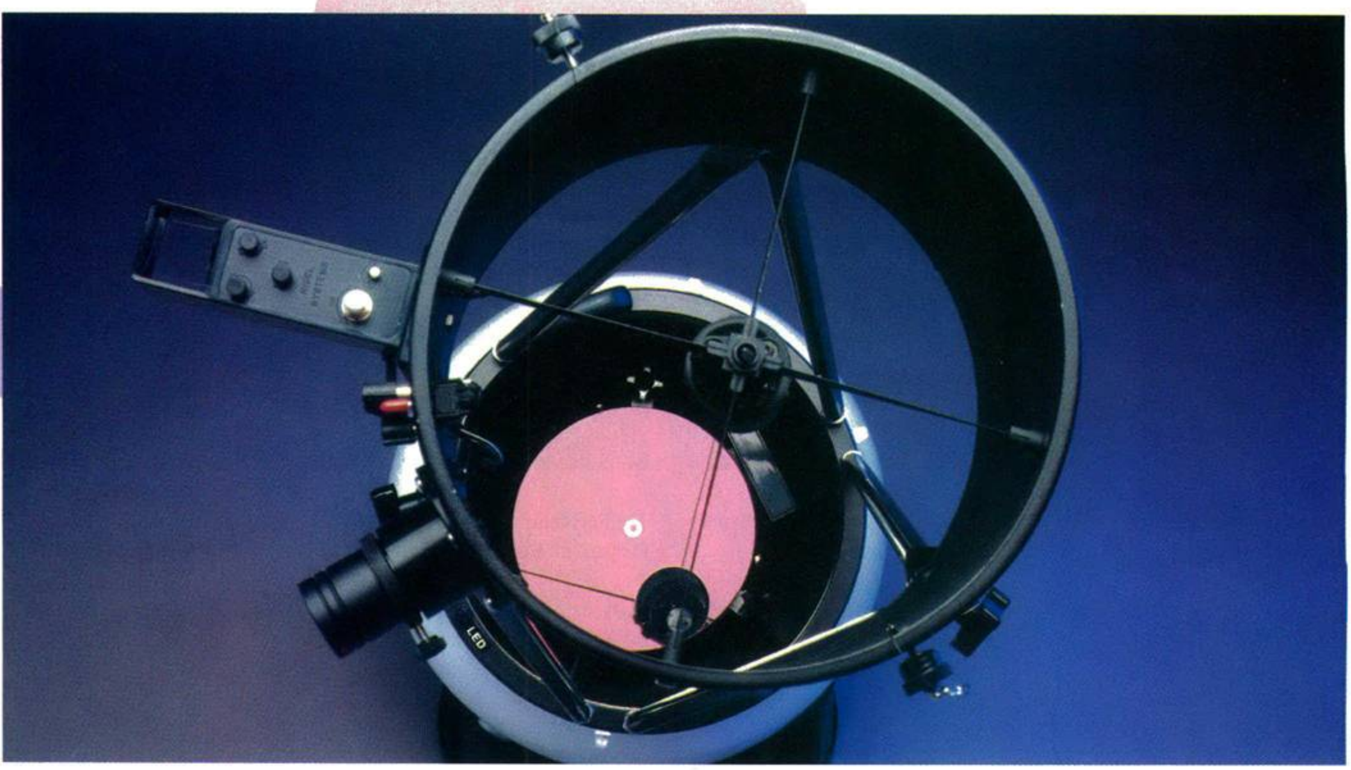
Far and away the greatest concerns with the design relate to its low bearing position. The "altitude bearing" is only inches from the primary mirror, leaving the scope with a four-foot moment arm to the upper tube assembly and the attendant balance problems. While MAG 1 Instruments has done an admirable job in keeping the upper tube's weight low, the quality of its components suffers. The Lumicon 1¼" helical focuser proved frustrating from the start. The plastic construction has a poor feel, and non-parfocal eyepieces require many twists to reach focus. An f/6 instrument needs to employ a 2" focuser to take advantage of potential field of view. The widest field of view that can be obtained with an 8-inch f/6 using an eyepiece in a 1¼" barrel is 1½°. A 2" 35mm Panoptic in this scope could stretch that to a full 2° for those breathtaking sweeps of summer Milky Way star clouds. Even heavier 1¼" eyepieces send the upper end plummeting to the horizon and twisting. The scope was able to hold its position with a 9mm Nagler eyepiece only at altitudes above 45°. In addition to the focuser problems, a small finder scope at the front end is ruled out by balancing problems. You'll have to become adept with a 1x finder and a star chart. The user has some control over the balance issues by adjusting the friction on the sphere. This bearing surface can be made smoother or rougher by applying denatured alcohol or wax, respectively. While roughing up the bearing addresses some of the balance issues, it results in compromised fluidity.

Observing with the Portaball

At a dark site, Phoenix scope-builder Pierre Schwaar and I compared the Portaball to two 8-inch f/4 instruments of his making. Not only was Castor cleanly split into two Airy disks at 170x, but it was also apparent that the western component is slightly brighter and more yellow. The Trapezium in the Orion Nebula was similarly impressive, showing the E and F components readily. In these cases, the shorter focus rich-field scopes kept up with the Portaball with some difficulty. Diffraction rings inside and outside of focus revealed a minor undercorrection to the mirror's figure that had a negligible effect on performance.

Back at lower power, the extent of the Orion Nebula was nearly identical between the three competing scopes. Using a magnitude sequence around the globular cluster NGC 2419, we found that a 14.7-magnitude star was held steadily while one labeled 15.4 could be seen less than half the time. The f/4 instruments had more difficulty holding the fainter star.

But the Portaball really shone in a contrast comparison. The Flame Nebula, NGC 2024, showed far more detail in this instrument, while the light of a nearby 3rd-magnitude star brightened the field too much in both RFTs. This superior contrast would be repeated using diverse objects on other nights. Although neither Jupiter nor Saturn were available for viewing during the test period, the look at a four-day-old crescent moon was revealing. The detail in the earthshine was spectacular, appearing to be unaffected by the brightness of the lit crescent. Rays emanating from craters were more apparent than I'd ever seen. The sunlit edge of the moon met with a black surrounding sky. Keep this in mind if you are weighing this scope against a competing Schmidt-



Looking through the Portaball's spider into the primary mirror reveals the scope's radical design departure. It is highly portable and easy to use.

Cassegrain, which typically will not perform in this manner. In many discussions regarding contrast with optical pundits, the subjects of small secondary obstruction, tube darkening, and mirror smoothness were raised. I think the Portaball's superior contrast may be due to the combined effect of all three of these factors.

What You Get and What You Need

For the base price, you get a fully functional 8-inch telescope with such features as covers for the sphere, telescope, and mirrors, a container for the truss poles, and a collimating tool. You may be disappointed not to receive eyepieces. MAG 1 recommends three- and four-eyepiece sets, and will act as a dealer for Tele Vue eyepieces that will maximize performance. If you have another $300 to spend, three additional packages are available. Highly recommended for all applications of the telescope are the nylon light shroud and tube extension, which sell for $89. Both attach easily, and shield both mirrors from stray light that intrudes at even the darkest locations. The sphere electrical package ($115) consists of a battery in the sphere, a cooling fan for the primary mirror, and a primary-illuminating LED. If you don't set up at night, you may not need any of these items. I found that the mirror equilibrated well, but I never put it though tests of excruciating temperature extremes. The lack of ventilation from the rear may necessitate the electrical package for those who store the telescope in a heated house. Finally, people living in humid climates may opt for the upper tube assembly electrical package ($98). Heaters for the secondary mirror and finder will keep you observing longer on moist nights. This package also provides a pulsing LED that illuminates the secondary. Again, this option becomes necessary only if you plan to collimate after dark. Power is delivered to the upper tube assembly package from the battery in the sphere via a cable with convenient plugs at both ends. I found all of these accessories to be as slickly produced as the telescope itself.

Is the Portaball for You?

MAG 1 Instruments has produced a telescope that rises above the common 8-inch Dobsonian. With a manufacturer-direct price of $1,195, this feat has its price, but perhaps it should. Optical and mechanical performance have been optimized for this design. The telescope is constructed of generally durable components. And there is no more portable 8-inch telescope available. Experience shows that a portable, simple scope gets used. I was not averse to bringing it out as a second scope in my truck's cab while a 20-inch scope rode to the site in the bed.

The 8-inch Portaball is not without its annoyances involving the components mounted on the lightweight upper tube assembly, and these are being addressed by the manufacturer. However, some concerns inherent in the design — such as lack of predictable motions, susceptibility to wind, and balance — may prove difficult, if not impossible, for MAG 1 Instruments to overcome.

Perhaps more important to the overall success of the 8-inch Portaball are the smaller touches that reveal the telescope is made by a veteran who remains close to the hobby. Details in construction suggest that Pete Smitka actually uses telescopes often, and is concerned with improving them. He supports his products effectively. He actively tours the country's major star parties each year. If you're at one of these many events, look for the 8-inch Portaball. ▣

Tom Polakis is a longtime observer and telescope user. He is currently writing a series of articles for Astronomy *on viewing deep-sky objects.*

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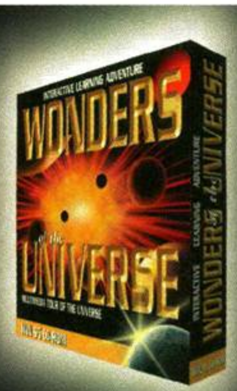

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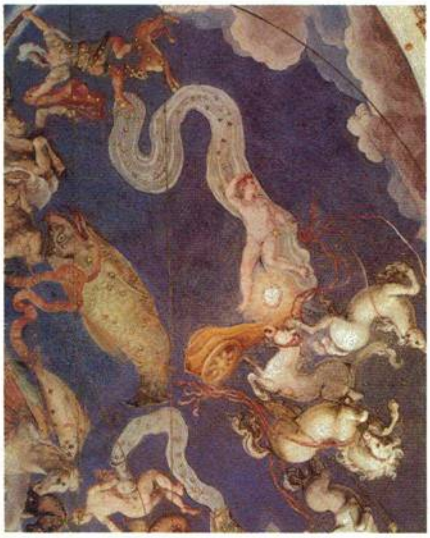
Eridanus & Fornax



Artwork at left originally published in *The Glorious Constellations*, © 1991 Harry N. Abrams, Inc.

Clear winter nights offer hardy observers a witch in the waters of the River and a dwarf in the flames of the Furnace.

by Tom Polakis

PRECEDING THE MIGHTY Hunter Orion on its trek to the meridian are the often neglected star fields of Eridanus the River and Fornax the Furnace. It's a shame this region doesn't get the attention it deserves, as it is home to some detailed galaxies, a couple of fine planetary nebulae, and nearby galaxy clusters.

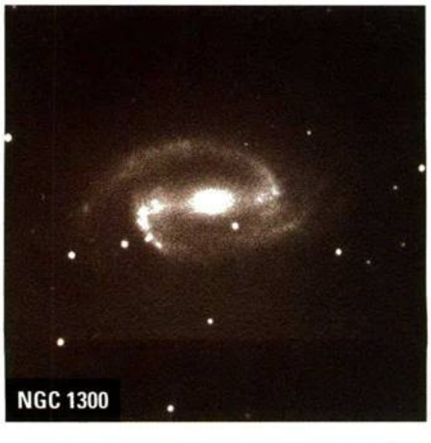
Eridanus has the sixth largest area of the 88 constellations, yet it is devoid of Messier objects and holds only three members of the Herschel 400 list. The most prominent feature of the constellation is a large U-shaped group of mainly 4th-magnitude stars whose eastern end opens toward Orion. It is the most easterly constellation in the ancient celestial sea and spans a remarkable range of declination. To find Eridanus look near the star Rigel in Orion. Then follow its sinuous path south to the star Achernar at –58°. One of the ten brightest stars in the sky, Achernar is a type B star located 144 light-years away.

Fornax holds only five stars brighter than magnitude 5. Despite its sparse stellar appearance, there are several deep-sky treats within the constellation's boundary.

Our tour begins with **NGC 1097**, a barred spiral galaxy 2° north of the 4th-magnitude star Beta (β) Fornacis. The galaxy's core appears as a bright disk in an 8-inch telescope. In a large telescope at high magnification, an interesting ring around the nucleus may be revealed. This kind of star-forming structure is not uncommon in active barred spirals. Professional instruments resolve the ring into two spiral arms filled with star clumps that may be newly forming globular clusters. The size of this feature is about 7,000 by 4,000 light-years.

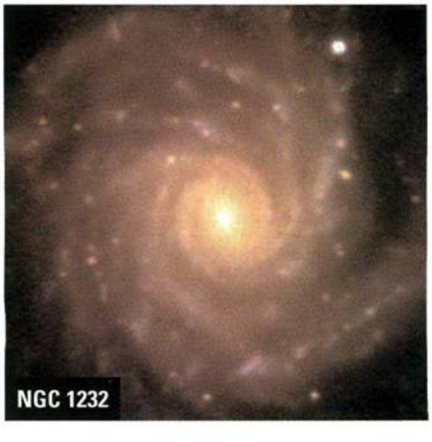
Extending in a position angle of 135° is the galaxy's faint bar. Its even fainter spiral arms are visible with more difficulty. The arm that wraps around to the east from the northwest tip of the bar is more prominent. The small galaxy **NGC 1097A** lies just beyond the northwest end of the bar.

Our next object is the **Fornax Dwarf**. This nearby galaxy was discovered in 1938 by Harlow Shapley. Though its distance is 430,000 light-years, this Local Group member is the



NGC 1300

David J. Pontzer



NGC 1232

Al Kelly

closest dwarf companion to the Milky Way and one of two such neighbors that hold globular clusters. Recent studies have connected companion galaxies and globular clusters of the Milky Way with giant orbital streams. There is also evidence that the Fornax Dwarf may be related to the globular clusters Palomar 14 and Palomar 15 on the other side of the sky.

Large aperture is actually a disadvantage when looking for the Fornax Dwarf galaxy. The best views may be obtained in 6- to 8-inch telescopes that are capable of providing at least a 2° field of view. Moving the scope back and forth across this field brings out a haze just brighter than the background sky. Though the Fornax Dwarf presents a challenge to most instruments, the galaxy's brightest globular clusters are easier to find.

At the northern edge of the galaxy lies **NGC 1049**, which is nearly 30" across and has a bright center. At least five other globular clusters can be found in the Fornax Dwarf, and all warrant a look in large scopes.

IC 2118

Bill and Sally Fletcher

Scanning north into Eridanus we find the spiral galaxy **NGC 1232**. In a 6-inch reflector, it appears to be a large, faint haze that brightens to the core. Through a 12-inch, the core is decidedly nonstellar and traces of spiral structure become evident. On the best nights, this Sc spiral shows multiple arms that are reminiscent of M74. NGC 1232 is roughly 60 million light-years away.

Pan the telescope just over 2° north of the star Tau^4 (τ^4) Eridani to locate the barred spiral **NGC 1300**. The *Hubble Atlas of Galaxies* lists NGC 1300 as the prototype of the pure SBb(s) galaxies. The capital B in this classification refers to the bar that runs through the center of the spiral. The small b indicates that the bar has a smooth texture, while the s subgroup means the spiral arms emerge from the bar at right angles. This shape classification is apparent through the eyepiece. A 13-inch telescope will show the brightest region is three times as long as it is wide, with bright nodules showing up at each end. The arms are faintly visible, wrapping tightly back around the bar. Look first for the more prominent southern arm which begins at the east end of the galaxy.

NGC 1399 and NGC 1404

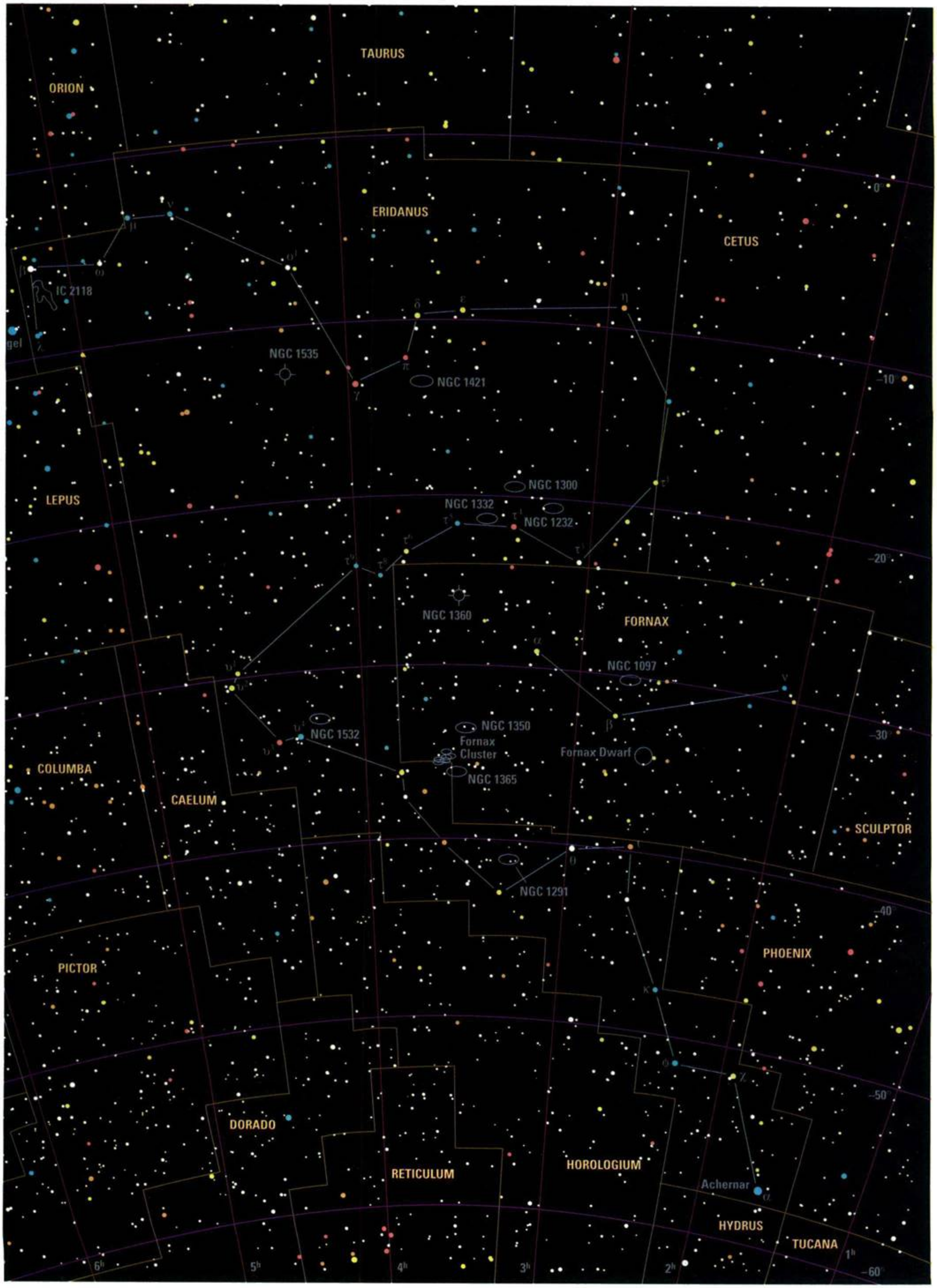
Anglo-Australian Telescope Board

Midway between the stars Tau^4 (τ^4) and Tau^5 (τ^5) Eridani is the spiral galaxy **NGC 1332**. In most telescopes, it appears to be no more than a bright core with gradually fading wings that bring its size to 3' by 1'. The galaxy points to the east and toward a fainter galaxy, NGC 1331. One word of caution: Most star charts that indicate the orientation of NGC 1332 carry over an error from the *Third Reference Catalogue of Bright Galaxies*. In that reference, NGC 1332's position angle is listed as 148°. In fact, its position angle is closer to 115°.

Hopping back from Eridanus to Fornax, we find the large planetary nebula **NGC 1360**. Measurements of its 11th-magnitude central star indicate a distance of 1,140 light-years. A 10-inch scope at a dark sky site shows the nebula to be 6' long and only half as wide. A thick, dark area surrounds the central star suggesting a tenuous ring structure. This detail is improved dramatically with a nebula filter.

The bright galaxies of the **Fornax Galaxy Cluster** are relatively near to our own galaxy. This closeness provides observers with small scopes an opportunity to do some great galaxy hopping. The Fornax Cluster has hundreds of galaxies, though it is still smaller than the Virgo Cluster. The relative distances of these two galaxy clusters is still a subject of debate. Most studies place the center of the Fornax Cluster at about 55 million light-years, slightly more distant than the Virgo Cluster.

NGC 1350 lies a couple of degrees northwest of the most dense region in


TAURUS
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NGC 1360
FORNAX
NGC 1097
NGC 1532
NGC 1350
Fornax Cluster
Fornax Dwarf
NGC 1365
COLUMBA
CAELUM
SCULPTOR
NGC 1291
PHOENIX
PICTOR
DORADO
RETICULUM
HOROLOGIUM
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TUCANA
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–20°
–30°
–40
–50°
–60°
6h
5h
4h
3h
2h
1h

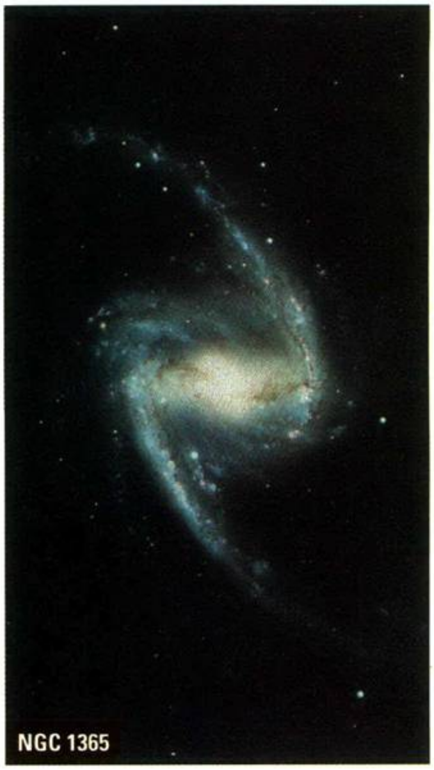
the Fornax Galaxy Cluster. In large telescopes, this bright galaxy shows a bar about 3' long surrounded by a thin ring of spiral arms.

Next on our list is **NGC 1365**. This galaxy shows the most spectacular example of barred spiral structure in the heavens. The bright halo at its center is 2' across and brightens to a sharp central disk. The bar, oriented east/west, is 4' long.

The galaxy's spiral arms are easy to see in an 8-inch telescope when the galaxy is placed well above the horizon. Begin by looking for the better-defined arm that extends northward from the west end of the bar. A slightly fainter eastern arm is placed in near-perfect symmetry to this one. Recent period measurements of Cepheid variable stars by the Hubble Space Telescope put this galaxy at 60 million light-years away.

A circular area only 2° across defines the heart of the Fornax Galaxy Cluster. More than 100 galaxies pepper the region. There are 15 galaxies in the cluster that are brighter than 13th magnitude. This makes them accessible to small telescopes. Gawking at the entire collection of galaxies in one view is irresistible, but some of the inner members are worth a closer look.

Start with **NGC 1374**. This small, bright glow has a fainter companion (NGC 1375) less than 3' to the south. From there, pan one quarter of a degree southeast to reach **NGC 1379**, a perfectly circular elliptical galaxy. One half of a degree north lies **NGC 1380**. This barred spiral appears as a bright oval haze with a 13th-magnitude star just to the west. The armless S0 spiral galaxy **NGC 1381** shows a tiny lenticular form, while **NGC 1387** is a small, round spiral that appears to be a formless glow in large telescopes. Finally, in the same high-power field of view are the twin elliptical galaxies **NGC 1399** and **NGC 1404**. Both galaxies share a common type and appear, through the eyepiece, to be round smudges of


NGC 1365

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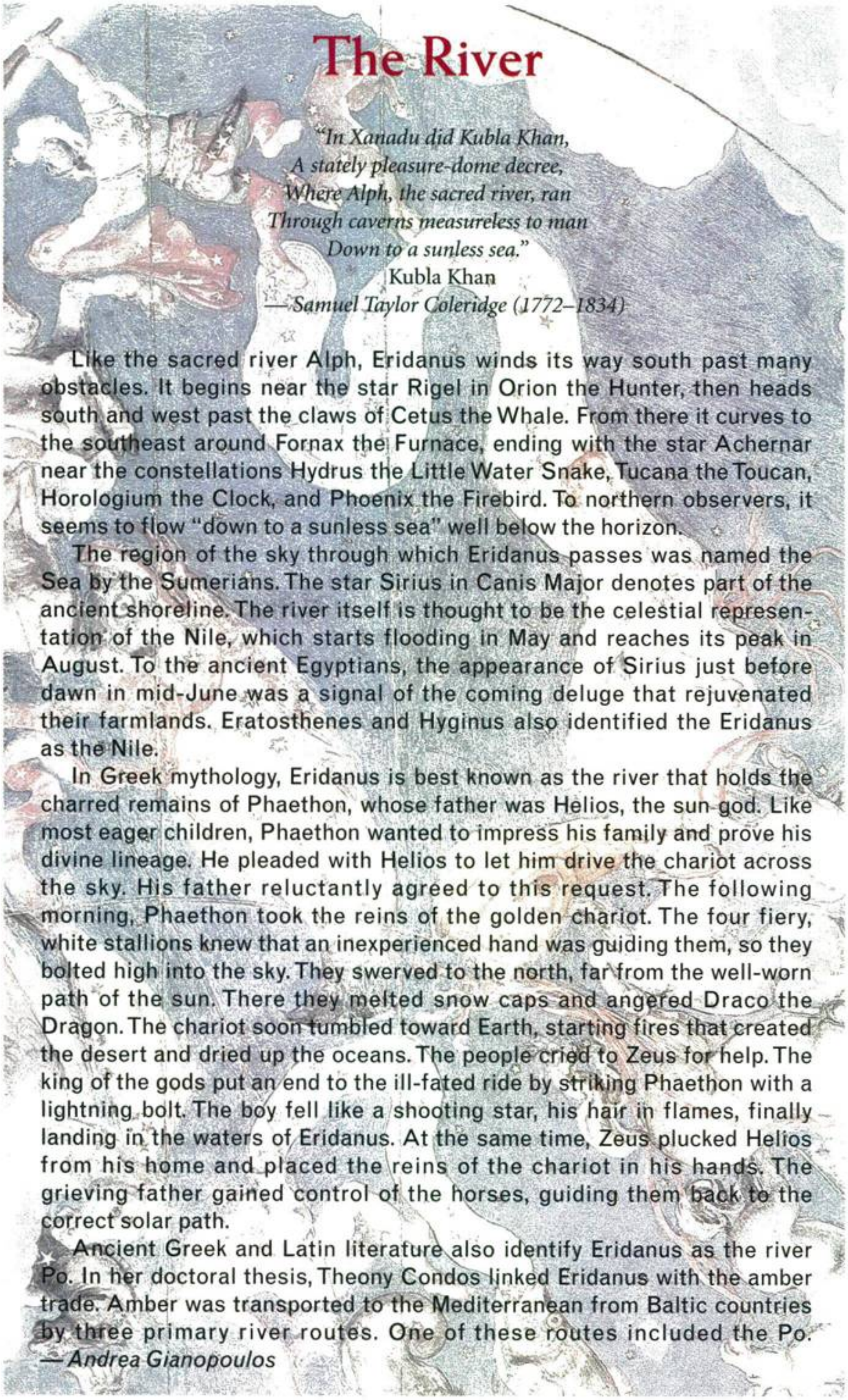
Deep-Sky Objects in Eridanus and Fornax

Object	R.A. (2000.0)	Dec.	Mag.	Size/Sep./Per.	Type	Notes
Fornax Dwarf	2h39.9m	–34°32'	8.1	12.0' by 10.2'	Gal	dE2
NGC 1097	2h46.2m	–30°14'	9.2	10.5' by 6.3'	Gal	SB(rs)bc
NGC 1232	3h09.8m	–20°35'	10.0	6.8' by 5.6'	Gal	SAB(rs)c
NGC 1291	3h17.3m	–41°08'	8.5	11.0' by 9.5'	Gal	SB(s)0
NGC 1300	3h19.7m	–19°25'	10.4	5.5' by 2.9'	Gal	SB(s)bc
NGC 1332	3h26.3m	–21°20'	10.5	5.0' by 1.8'	Gal	S0
NGC 1350	3h31.1m	–33°38'	10.3	6.2' by 3.2'	Gal	SAB(r)ab
NGC 1360	3h33.3m	–25°51'	9.4	390"	PN	—
NGC 1365	3h33.6m	–36°08'	9.3	8.9' by 6.5'	Gal	SB(s)b
NGC 1374	3h35.3m	–35°14'	11.0	2.6' by 2.4'	Gal	SA(rs)0
NGC 1379	3h36.1m	–35°27'	11.0	2.6' by 2.5'	Gal	E0
NGC 1380	3h36.5m	–34°59'	10.0	4.8' by 2.8'	Gal	SB(s)0
NGC 1381	3h36.6m	–35°18'	11.5	2.6' by 1.0'	Gal	S0
NGC 1387	3h37.0m	–35°31'	10.8	3.1' by 2.8'	Gal	SAB(s)0
NGC 1399	3h38.5m	–35°27'	8.8	8.1' by 7.6'	Gal	E1
NGC 1404	3h38.9m	–35°35'	9.7	4.8' by 3.9'	Gal	E1
NGC 1421	3h42.5m	–13°29'	11.4	3.1' by 1.0'	Gal	Sbc pec
NGC 1532	4h12.1m	–32°52'	9.9	11.2' by 3.2'	Gal	Sb pec
NGC 1535	4h14.2m	–12°44'	9.6(p)	18"	PN	—
IC 2118	5h06.9m	–7°13'	—	180' by 60'	DN	Witch Head Nebula

Object: Designation in Messier, NGC, or other catalog. **R.A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep./ Per.:** Size in arcminutes or arcseconds, separation in arcseconds, or period in days. **Notes:** Hubble type for galaxies or type for variable stars.



The River

"In Xanadu did Kubla Khan,
A stately pleasure-dome decree,
Where Alph, the sacred river, ran
Through caverns measureless to man
Down to a sunless sea."
Kubla Khan
—Samuel Taylor Coleridge (1772–1834)

Like the sacred river Alph, Eridanus winds its way south past many obstacles. It begins near the star Rigel in Orion the Hunter, then heads south and west past the claws of Cetus the Whale. From there it curves to the southeast around Fornax the Furnace, ending with the star Achernar near the constellations Hydrus the Little Water Snake, Tucana the Toucan, Horologium the Clock, and Phoenix the Firebird. To northern observers, it seems to flow "down to a sunless sea" well below the horizon.

The region of the sky through which Eridanus passes was named the Sea by the Sumerians. The star Sirius in Canis Major denotes part of the ancient shoreline. The river itself is thought to be the celestial representation of the Nile, which starts flooding in May and reaches its peak in August. To the ancient Egyptians, the appearance of Sirius just before dawn in mid-June was a signal of the coming deluge that rejuvenated their farmlands. Eratosthenes and Hyginus also identified the Eridanus as the Nile.

In Greek mythology, Eridanus is best known as the river that holds the charred remains of Phaethon, whose father was Helios, the sun god. Like most eager children, Phaethon wanted to impress his family and prove his divine lineage. He pleaded with Helios to let him drive the chariot across the sky. His father reluctantly agreed to this request. The following morning, Phaethon took the reins of the golden chariot. The four fiery, white stallions knew that an inexperienced hand was guiding them, so they bolted high into the sky. They swerved to the north, far from the well-worn path of the sun. There they melted snow caps and angered Draco the Dragon. The chariot soon tumbled toward Earth, starting fires that created the desert and dried up the oceans. The people cried to Zeus for help. The king of the gods put an end to the ill-fated ride by striking Phaethon with a lightning bolt. The boy fell like a shooting star, his hair in flames, finally landing in the waters of Eridanus. At the same time, Zeus plucked Helios from his home and placed the reins of the chariot in his hands. The grieving father gained control of the horses, guiding them back to the correct solar path.

Ancient Greek and Latin literature also identify Eridanus as the river Po. In her doctoral thesis, Theony Condos linked Eridanus with the amber trade. Amber was transported to the Mediterranean from Baltic countries by three primary river routes. One of these routes included the Po.
—Andrea Gianopoulos

similar size. Look for the 13th-magnitude star that seems to touch the nucleus of NGC 1399.

Leaving the galaxies of Fornax far to the north, we head to the ringed galaxy **NGC 1291**. Unlike the small circumnuclear ring seen in NGC 1097, the ring around NGC 1291 is a huge band that rests outside the galaxy's main halo. Though a telescope won't show this ring, it will bring out an intense central core and a surrounding oval shape. The galaxy is bright enough to be seen with an 80mm finderscope, yet it is 28 million light-years away. If you have trouble finding NGC 1291 in your references, look for NGC 1269. The two catalog numbers refer to the same galaxy.

Use the 4th-magnitude stars 43 and 41 Eridani to guide the scope to **NGC 1532**. Presented almost edgewise, the galaxy appears nearly eight times as long as it does wide. A bright association of stars in the southwestern spiral arm appears as a similarly elongated streak in a 10-inch telescope. There is a soft glow from the interacting elliptical galaxy, NGC 1531, just northwest of the central hub of NGC 1532.

Those seeking a challenge for their large scopes should try **ESO 359–29** only 12' to the southeast of NGC 1532 and NGC 1531. The entire system is 70 million light-years away.

NGC 1421 is an interesting peculiar galaxy located in the middle of Eridanus. It has an oval form with a sharp edge and little central brightening — similar to M82. Some mottled detail comes into view with a magnification of 200x. This detail includes traces of the galaxy's long spiral arms. Look for a dark, obscuring cloud halfway to the end of the northern arm.

Although small, **NGC 1535** is a remarkably detailed planetary nebula. In a 6-inch telescope, it has a sharply defined disk with a surrounding envelope. Its pale blue tone becomes subtly apparent in a 13-inch. At 300x, a dark hollow immediately surrounds the bright central star. The inner disk is sharp and bright, while the surrounding shell faintly extends the size to 30". The best views of this planetary nebula require great seeing conditions and a patient observer.

We move from the tiny to the huge with the **Witch Head Nebula** (IC 2118). Dark skies and a high-contrast telescope are the prerequisites for detecting this faint reflection nebula. It shines by reflecting the light of Rigel only 3° to the east. A good starting point for finding the Witch Head is two-thirds of the way from Rigel to 3rd-magnitude Beta (β) Eridani. Here you will see the north end of the Witch Head. Use your lowest magnifications and move south from this point. The nebula is brightest at this northern end, and looks like a crescent-shaped mist 1.5° long. Keen observers with good sky conditions may spot the profile of IC 2118's namesake witch. An 8-inch rich-field telescope brings out the brightest portions of her face. ◼

Tom Polakis is an aerospace engineer living in Arizona. His primary astronomical interests are deep-sky observing and photography.

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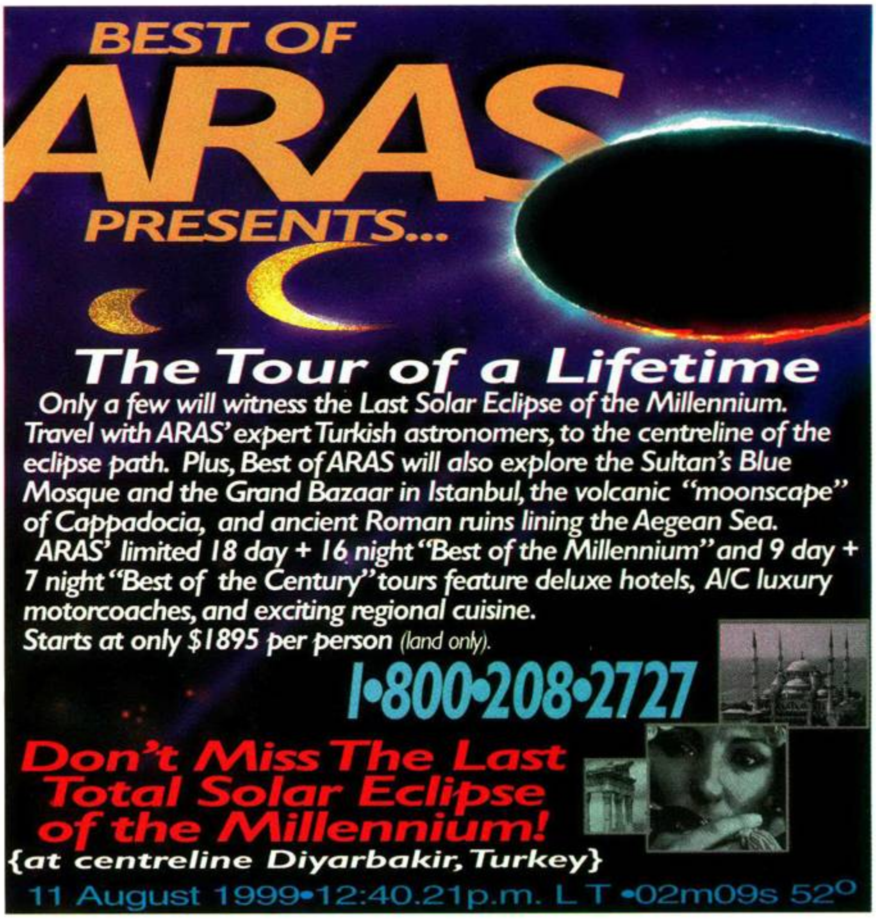

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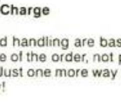

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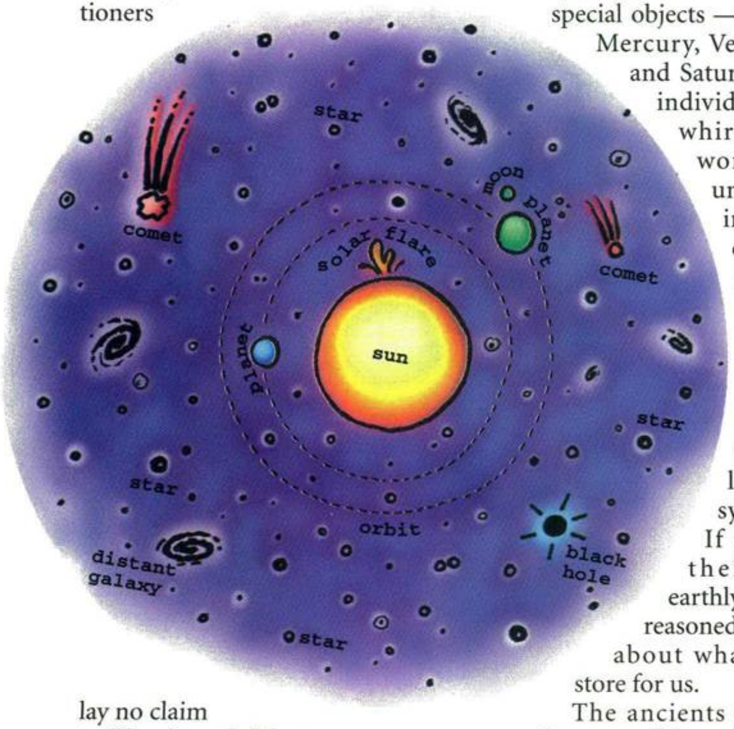
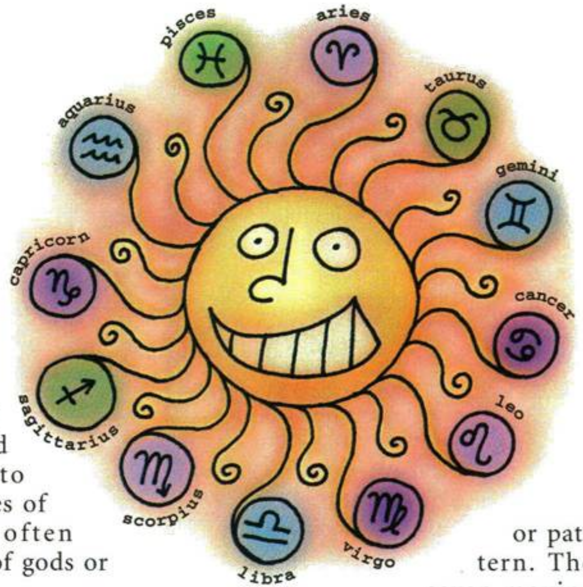
Astronomy vs. Astrology, Meteors

Q: What is the difference between astrology and astronomy? — *Kourtni Brown and Mandy Husted, Sullivan Middle School, Rock Hill, South Carolina*

A: Astronomy is the science that investigates objects and processes beyond Earth. Using careful observations and experiments, astronomers try to establish what the universe consists of, what the rules are by which celestial objects work, and how we on Earth fit into the larger scheme of cosmic evolution. As is true for every science, astronomy might be termed a "progress report" — whose practitioners lay no claim to "final truth," but acknowledge that they are always in the midst of an ongoing series of investigations to try to unveil what nature is really like.



In contrast, astrology is an ancient and magic-based belief system, which claims that the positions of certain objects in the sky determine (or at least predispose) some aspects of our personalities or destinies. Astrology was born thousands of years ago, at a time when the world seemed a mysterious and overwhelming place to humanity and the causes of natural events were often ascribed to the actions of gods or other supernatural beings.



When they looked at the sky, the ancients noticed that, while the whole sky turned around us once a day, seven special objects — the sun, the moon, Mercury, Venus, Mars, Jupiter, and Saturn — had their own individual motions in this whirling scheme. In a world-view where all unusual behavior was interpreted as a sign of the gods or spirits, it made perfect sense that these seven objects with the power to move about in the sky must either be gods themselves, or at least significant symbols of the gods. If we could connect their motions with earthly events, the ancients reasoned, we might get clues about what the gods had in store for us.

The ancients saw that the seven "power objects" did not wander through the whole sky, but confined their motion to a relatively narrow band, which came to be known as the zodiac. They divided the zodiac into 12 "signs" or sections, each of which was named for some prominent star group or pattern. The seven moving objects could be located among the zodiacal signs at any point in time.

So the essence of astrology is that at the magic moment when each of us is born, the positions of the sun, the moon, and the easily seen planets within the signs of the zodiac can tell a trained astrologer something about what is in store for our lives. Because all of us would like to know what lies ahead (especially when it comes to such questions as what we should do for a living, whom we should marry, and whether we will get sick or get better), astrology was a very tempting scheme. Wouldn't it be great if the sky could somehow tell you how to live your life better or how to be a more successful person?

Alas, while astrology might have made sense when the seven moving lights in the sky were thought to be supernatural beings (or their representatives), it makes no sense today when we know a lot more about them. The sun is a gigantic ball of super-hot gas, the planets are physical bodies orbiting the sun, and the moon is our rocky satellite. They are fascinating objects, very much connected with the evolution of *Astronomy* readers and other important cosmic processes (in ways the ancients could never have imagined), but they are mercifully

Astronomy: Terri Field

unconcerned with Sylvester Stallone's love life and those other personal details in our lives that worry astrology buffs.

Astrologers today say that while they don't understand *why* it works, the main thing about astrology is that it *does* work. They claim that a careful study of a horoscope can help them predict a client's personality or future. But such claims can be tested by careful experiments, just as any other claims about the natural world can be tested using the scientific method. Scientists and statisticians have performed more than 50 clever tests of astrological claims in the last few decades. And astrology has failed all of them.

For example, many astrologers will tell you that your sun-sign is connected with your choice of a profession. In other words, people for whom the sun was in certain parts of the sky when they were born might prefer one career over another, especially when it comes to personality-driven career paths. In the 1970s, economists James Barth and James Bennett of George Washington University found a perfect example: re-enlisting in the Marines. I think we would all agree that it takes a certain kind of personality to like the Marines enough to enlist again. If choosing such a career is connected with one's sun-sign, then if you charted the horoscope of thousands of re-enlistees, you should find that they did not fall randomly among the signs, but would cluster in those signs most closely matching the personality of a Marine. But when Barth and Bennett did their study, the re-enlistees were distributed equally among the 12 zodiacal signs. Astrology was no help in predicting who might like to be a life-long Marine. Nor is it useful in indicating who will become President, make a lot of money, or be successful in love.

If astrology fails all such tests, why then do so many people believe in it and sing its praises? Most astrologers today are amateur psychologists — their horoscope readings and newspaper descriptions are vague and reassuring. They say things that any person, with a complex set of personal and work relationships, might be able to interpret as relevant. Mine, the other day, said "beware of concerns about the opposite sex." Who could not find a way to apply that to his or her own life? — *Andrew Fraknoi, Foothill College; former executive director of the Astronomical Society of the Pacific*

Q: How big are the meteors that we see as shooting stars? What factors affect their color, length, and intensity?

— Richard J. Kinney, Clovis, California

A: The vast majority of the meteors you see at night are actually smaller than a grain of sand. However, several hundred tons of meteors burn up in the atmosphere every day.

Most meteors are yellowish or white, with the color depending on how bright they are (your eyes have a hard time discerning color in faint objects) and how hot they get. Some extremely bright meteors can appear blue or white.

The intensity of the meteor depends on how hot it gets, how big it is (a bigger meteor can generate more energy because there is more material to heat up), and how fast it is coming.

The length of the trail the meteor leaves on the sky depends mostly on viewing angle: If the meteor is coming across your line of sight you might see a long trail, but if it is coming straight at you, you won't see any trail at all (and you'd better hope the meteor burns up!). — *Phil Plait, Advanced Computer Concepts, Inc.*

A sliver of space rock no bigger than a grain of sand caused this meteor trail. Keith A. Corban

CONTACT INFO

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P.O. Box 1612, Waukesha, WI 53187. Please tell us your full name and where you live. *Astronomy* regrets that due to the large volume of mail, we are unable to publish answers to all questions or respond to each one individually.

PRODUCTS

Extend Your View

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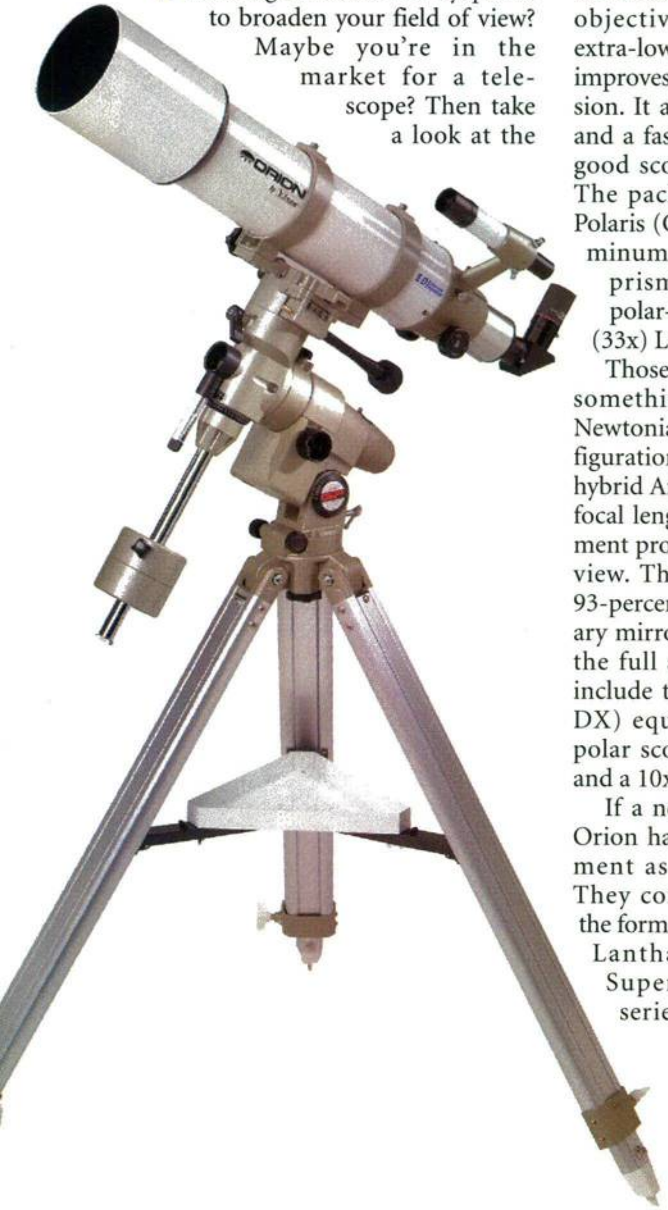

First on the docket is the 4-inch VX102-ED GP apochromatic refractor. This model features a two-element objective that incorporates special extra-low dispersion (ED) glass, which improves the telescope's color transmission. It also has a 665mm focal length and a fast f/6.5 focal ratio, making it a good scope for wide-field observing. The package includes Orion's Great Polaris (GP) equatorial mount and aluminum tripod, a 6x30 finder scope, prism star diagonal, illuminated polar-alignment scope, and a 20mm (33x) Lanthanum eyepiece.

Those who favor reflectors also have something new to try. The classical Newtonian and Maksutov optical configurations have been combined in the hybrid Argonaut 6-inch GP-DX. With a focal length of 900mm, this f/6 instrument provides a pleasingly wide field of view. The two Pyrex mirrors boast a 93-percent reflectivity, and the secondary mirror is just 28mm (18 percent of the full aperture). Standard features include the Great Polaris Deluxe (GP-DX) equatorial mount, illuminated polar scope, 2-inch Crayford focuser, and a 10x50 achromatic finder scope.

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▶ Orion Telescopes and Binoculars, P.O. Box 1815, Santa Cruz, CA 95061; phone, (800) 447-1001; fax, (831) 763-7000; e-mail, sales@oriontel.com; website, http://www.oriontel.com. VX102-ED GP: $1,329. Argonaut 6-inch GP-DX: $1,999. Lanthanum Superwides: 22mm ($222), 17mm ($222), 13mm ($217), and 8mm ($205).

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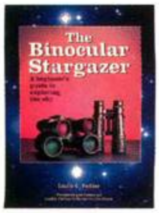

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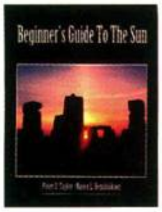

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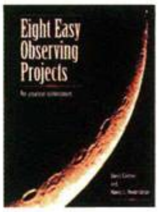

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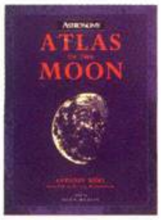

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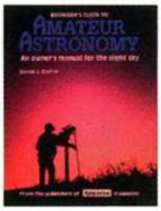

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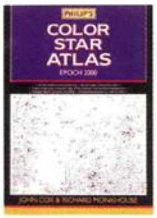

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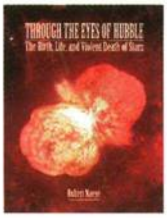
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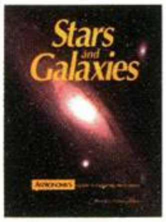

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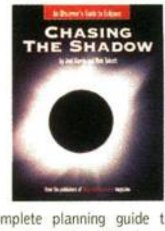

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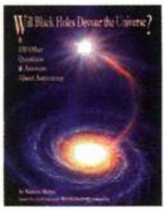

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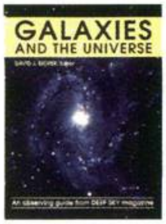

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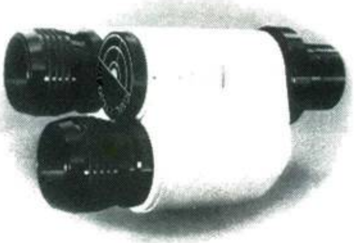

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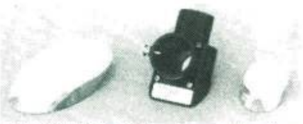

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SR-V 3200 NEW FILM

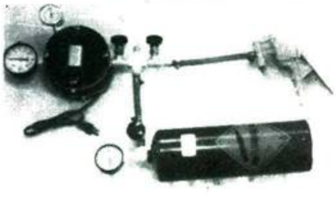
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**



MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5'' plates and film up to 5X7''. Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$75**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. †U.S. Patent 4,448,500

Specify Camera and Telescope type.

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2'' or 1¼''.

NEWTONIAN EASY-GUIDER	**$189.50**
48mm Coma corrector/field flattener	**$285**
3X Relay Diagonal (see photo)	**$99.50**
Illuminated reticle eyepiece, pulsed	**$119.50**

Guider for Hasselblad **$489,** Mamiya 645 **$259**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$249.00**
Adapter for Hasselblad **$299,** Mamiya 645 **$98**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

GIANT EASY-GUIDER™

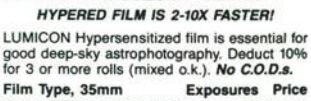
For Celestron-11, C-14, and the 10-12'' Meade. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) .... **add $179.50**
Adapter for Hasselblad **$399,** Mamiya 645**$149**
Pentax 6X7 **add $139;** Pentax 645 **add $159**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** .... **$119.50** Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, pulsed.
2. **Cable release** for long exposures . **$9.95**
3. **Declination motor** (state telescope type) **$109**
4. **Dual-axis drive corrector** for telescope. This should be part of the telescope when purchased. Call LUMICON for details.
5. **LUMICON EASY-GUIDER** (selection to left) .
6. **LUMICON 48mm DEEP-SKY FILTER $199.50** This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.
7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

TRY PPF! HYPERSENSITIZED FILM



HYPERED FILM IS 2-10X FASTER!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	**Exposures**	**Price**
Kodak PPF-400, THE BEST!	36	**$14.95**
2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Gold 1000 fast, fine grain	12	**$13.95**
Fuji G800 fine grain color neg.	**24**	**$13.95**
Ektachrome 1600, fast slide film	24	**$14.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$8.50**

LUMICON® ACCESSORIES MEADE® TELESCOPES

TOLL-FREE ORDER LINE 1-800-767-9576 EXPERT INFORMATION 1-925-447-9570 FAX 1-925-447-9589
LUMICON, 2111 Research Drive, Suites 4-5, Livermore, CA 94550 OPEN M-F 9-5, SAT 9-1 PST

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc.	$29.50
2'' adapter for C-80, C-100 refractor	$39.50
2'' adapter for C-70, C-80F, C-100F fluorite	$39.50
2'' adapter for C-6, Comet Catcher, Meade 312	$30.00

EXTENSION TUBES

1'' long 1¼'' OD thread-in extension	12.00
2½'' long extension (holds 1¼'' filters)	19.50
4½'' long extension for 1¼'' eyepieces	$29.00
3'' long extension for 2'' eyepieces*	$29.00
2'' long extension for 2'' eyepieces*	$29.00

VIEWING ADAPTERS

2''/1¼'' reducing bushing, threaded 48mm*	$25.00
2''/T-thread adapter, threaded 48mm*	$25.00
T-thread/1¼'' adapter	$25.00
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	$59.50
Low profile star diagonal eyepiece holder	$16.00
Meade 2'' Diagonal/Giant Easy-Guider	$39.50

**Threaded to hold 48mm filters.*

LED FLASHLIGHT . $14.95

LUMICON LUMILITE™ Red LED Flashlight

This red LED flashlight preserves night vision. Uses 2 AA cells (incl.) which last 60-100 hours.

LUMILITE red LED flashlight	$14.95
STARLITE™ adj. red LED flashlight	$24.95

RICH FIELD! 2° in 8'' SCT

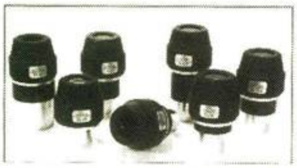
NOW ONLY
$99.95

LUMICON Rich-Field Viewer on C-8 with LUMICON 2'' star diagonal and 2'' eyepiece.

The LUMICON Rich-Field Viewer fits **all** commercial Schmidt-Cassegrain telescopes. It has a high-performance coated achromatic focal reducing lens with 50mm or 80mm clear aperture for **totally unvignetted viewing** with 2'' or 1¼'' eyepieces.

LUMICON Rich-Field Viewer (5-8'')	$99.95
Giant Rich-Field Viewer (10-14'')	$250.00

PENTAX 65° XL EYEPIECES



AMAZING performance! **All have** 20mm eye relief, adjustable eye guard, super multicoatings.

5.2mm F.L., 65° Apparent Field 1¼''	$279
7mm F.L., 65° Apparent Field 1¼''	$279
10.5mm F.L., 65° Apparent Field 1¼''	$269
14mm F.L., 65° Apparent Field 1¼''	$269
21mm F.L., 65° Apparent Field 1¼''	$269
28mm F.L., 55° Apparent Field 1¼''	$259
40mm F.L., 65° Apparent Field 2''	$299

MEADE 7'' - 16'' LX200 *NEW! 7'' - 10'' LX50*

8'' LX50
$1395

16'' LX200 $14,950

Meade 8'' LX200 Telescopes

LX50 - includes dec. motor, hand controller.
LX200 - full computer control w/64K obj. mem.
Tripod: extra for LX50; included for LX200

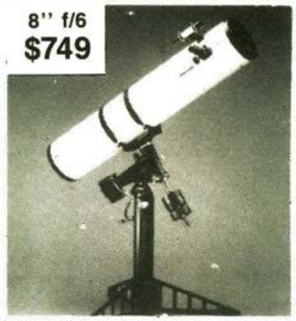
NOTE: A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your LX200.

NEW! 3.5'' f/14 ETX Maksutov ($20)	$595
ETX, showroom price *(no 8 month wait)*	$649
8'' LX10 w/wedge, hand controller ($65)	$995
Field Tripod for 8'' LX10 ($20 P&S)	$195
8'' LX50 w/wedge ($115 P&S)	$1395
Adj. tripod for 8-10'' SCT ($30 P&S)	$295
8'' LX200 w/computer ($65 P&S)	$2795
Wedge for photographing w/8'' LX200	$139
7'' LX50 f/15 Maksutov w/wedge ($125 P&S)	$1795
10'' LX50, f/10 w/wedge, dec. motor, hand controller ($155 P&S)	$1695
10'' LX200 w/computer ($155 P&S)	$3195
12'' LX200 (f/10 only)($215 P&S)	$4495
Super Wedge for photogr. w/10'',12'' LX200	$395
16'' LX200 f/10 w/tripod ($385 P&S)	$14,950
Dew Shields: 8'' .... $119; 10''	$129
12'' .... $189; 16''	$289

PHOTOGRAPHY ACCESSORIES

Cassegrain EASY-GUIDER 4''—8'', f/6 or f/10	$249
Giant EASY-GUIDER for 10''/12'' f/4-f/10	$395

MEADE STARFINDERS


8'' f/6
$749

New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive & finderscope (equat. only), mount, and 25mm (=48X) eyepiece. New DC motor runs on 4AA batteries.

6'' f/8 Dobsonian Starfinder ($46 P&S)	$349
6'' f/8 Equat. Starfinder 6(add $79 P&S)	$649
8'' f/6 Dobsonian Starfinder (add $59 P&S)	$449
8'' f/6 Equat. Starfinder 8 (add $89 P&S)	$749
10'' f/4.5 Dobsonian Starfinder ($85 P&S)	$599
10'' f/4.5 Equat. Starfinder 10 (add $99 P&S)	$879
12.5'' f/4.8 Dobsonian Starfinder ($95 P&S)	$895
16'' f/4.5 Dobsonian Starfinder (freight COD)	$1195
16'' f/4.5 Starfinder 16 (ship. freight COD)	$2695

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $50-$100 higher.

ACCESSORIES

LUMICON carries all Meade accessories.

Magellan computer; specify Dob. or Eq. ($15 ship)	$295
LUMICON 1¼'' UHC or O-III Filter	$99.50

Vinyl covers to keep dust-free (2 req.) for 6'' - **$10**; for 8'' - **$15**; for 10'' - **$20**; for 16'' - **$35**

SKY VECTOR™ $299!!

Includes Computer, Encoders, Hardware

LOW PRICE—from $299

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two *stars to align!*
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $299

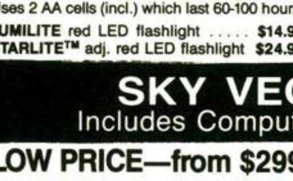
NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $349

Over 3600 objects! — Also includes planets and full visual descriptions.

NGC SKY VECTOR™ $439

12,000 Objects!— PC Serial Port



NGC SKY VECTOR with IDENTIFY (Sky Tour) mode, 12,000 object memory including the corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth, Meade 6-16'' Dobsonian.

Ultima 8, 9¼, 11 **add $25**, C-14 **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½'' f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	$285.00
LUMICON 2'' EASY-GUIDER	$189.50
2'' EASY-GUIDER (Mamiya 645)	$239.50
2'' Adapter for Pentax 6X7	$129.00
2'' Adapter for Hasselblad	$229.00
2'' Adapter for Bronica SQ-A	$175.00
2'' Extension for viewing	$26.00

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	$259.00

LUMICON ACCESSORIES

LUMICON, Livermore, CA 94550 (925) 447-9570 FAX (925) 447-9589

LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080	$199.50
UV/Dust Deal for Celestron C-8	$39.00
UV/Dust Seal for Meade 4''—8''	$39.00
UV/Dust Seal (lg.) for Meade 10''—12''	$89.50
UV/Dust Seal for Celestron-11, -14	$89.50

LOW PROFILE FOCUSERS New! Thread-on for Odyssey

FROM $69.50

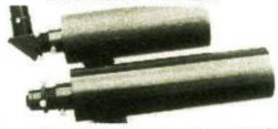
LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	$69.50
LUMICON 2'' Helical Focuser 1½'' high	$75.00
LUMICON Non-rotating Helical Focuser	$129.00
2'' Astro Systems focuser, only 2'' high	$139.00
3 handles for non-rotating focuser	$12.95
2''/1¼'' adapter w/48mm filter threads	$20.00
2'' LUMICON EASY-GUIDER	$189.50

LUMICON 50mm, 80mm SUPER-FINDER™



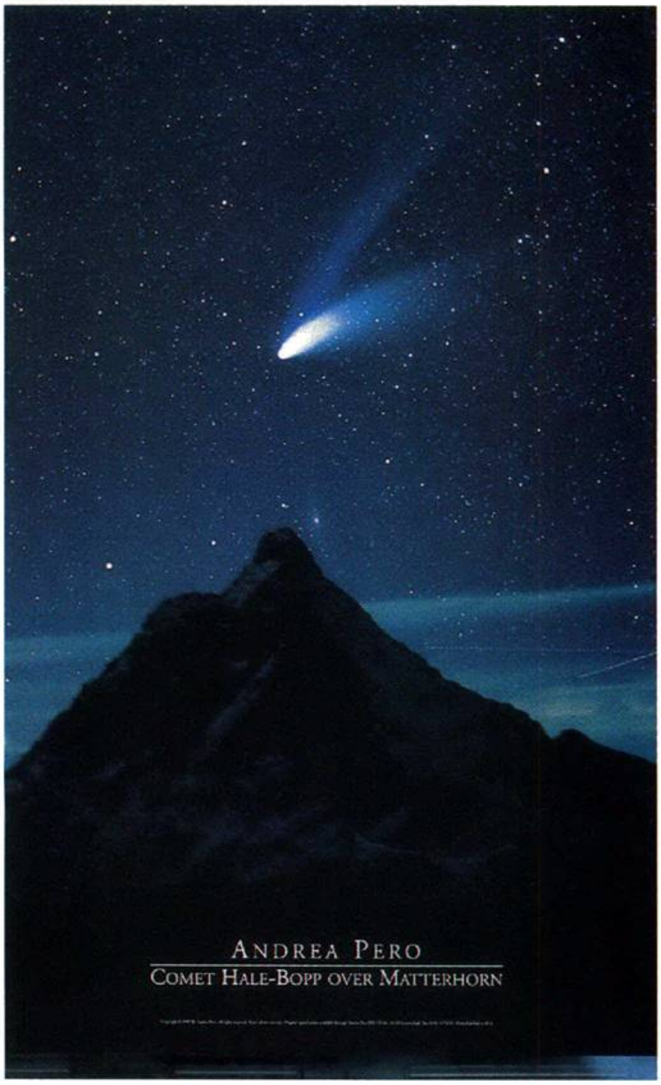
Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope $69.50, 45° version	$69.50
1¼'' straight-thru 80mm SUPER-FINDER	$199.50
1¼'' right-angle 80mm SUPER-FINDER	$209.50
1¼'' right-angle version, w/star diagonal	$239.50
25mm Cross-hair 1¼'' eyepiece (12X)	$59.00
Large mounting rings for 80mm Finder	$55.00
1¼'' Star Diagonal **$49**, Mounting Brackets,	$39.50
1¼'' 45° diagonal for correct left-right views	$49.00
1¼'' 90° Amici diagonal, correct left-right view	$59.50

PROTECTIVE DUST COVERS

Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼'' O.D. plug, seals focuser			4/$2
2'' O.D. plug	2/$2	3½'' O.D. plug	$1.50
1¼'', 1⅜''	3/$2	7½''	$10
1½''	2/$2	9½'', 10.4''*	$15
2''	2/$2	12½'', 12⅞''*	$20
2⅛''	2/$2	15.0'', 15.6'', 16''*	$28
5½''	$6	19'' (DS-16)	$35
*Fits Odyssey		21'' (Odyssey-II)	$35

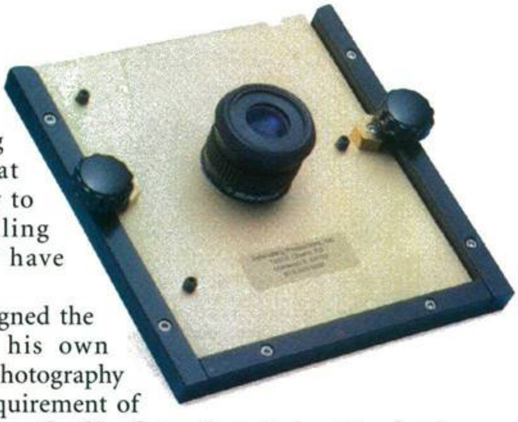


Matterhorn Fly-by

▶ Italian amateur astronomer and freelance photographer Andrea Pero is offering his photograph of Comet Hale-Bopp and the Matterhorn in a 24" x 33" poster. This full-color offset lithograph is printed on quality paper protected by a non-reflecting, anti-ultraviolet coating. The photo was taken at the comet's maximum brightness and height over the Matterhorn, which stands at 14,777 feet. Pero spent six days and nights on the Rosa Plateau, at an altitude of 11,550 feet, in the Italian Alps just to get the shot. He braved temperatures that hovered around 0° F and winds of 50 mph. The perfect view finally came on the evening of March 27, 1997.

The photograph was taken with a 50mm f/1.7 lens using Kodak PJM ISO 640 film. It is a one-minute exposure that was guided with two 4-inch f/11.6 refractors. Stars as dim as magnitude 10.6 can be seen along with the noctilucent clouds near the mountain.

Andrea Pero, C. P. 377, 16121, Genova, Italy; fax, (011-39) 0102474113. Comet Hale-Bopp over the Matterhorn: $32 with a 40-percent discount on orders of 10 or more mailed to one address.



Smile for the Camera

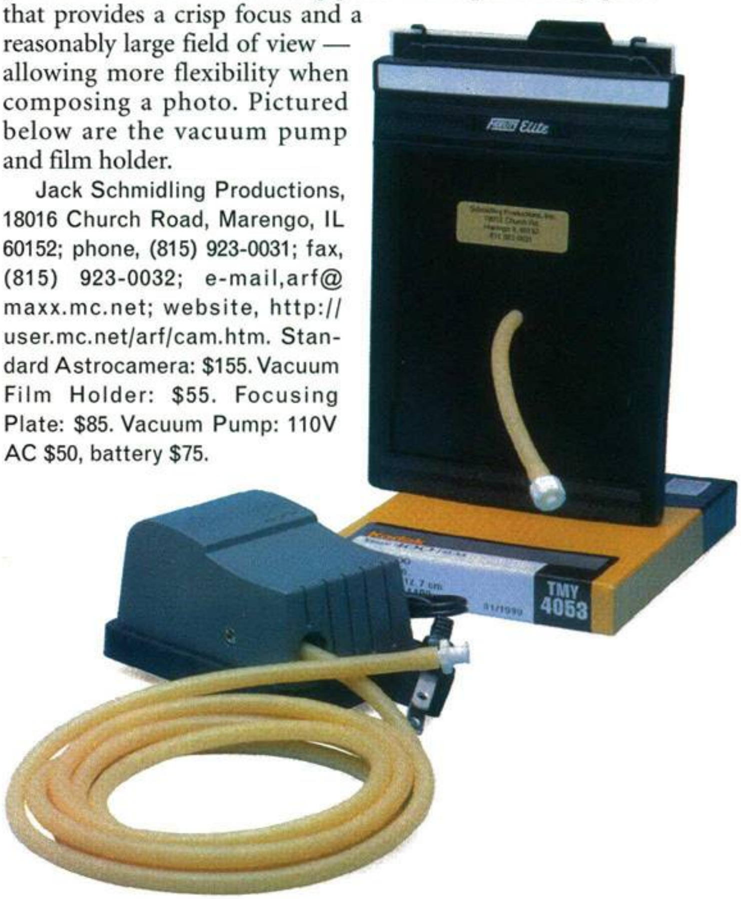
▶ If you're looking for a large-format camera that's easy to use, Jack Schmidling Productions may have the answer.

Schmidling designed the camera to meet his own large-format astrophotography needs. The first requirement of the design was to keep the film flat and precisely at the focal plane during exposure. The JSP camera accomplishes this with a patented 4x5 vacuum film holder. The vacuum is applied through a quick disconnect fitting that is supplied with the film holder. Two thumbscrews on either side of the camera clamp the film holder firmly in place.

Advantages include the camera's simplicity, ease of use, and the fact that the film plane is in the same place as a normal eyepiece. The negative also has nearly the same image scale as *Uranometria* star charts, when the camera is used with an 8-inch f/5 telescope.

The standard version (pictured above) includes a camera back to hold the 4x5 film holder, and a 2-inch tube that fits into a 2-inch focuser. The tube is threaded at the end to accept filters, coma correctors, and other accessories. Also pictured above is the focusing plate with a parfocal eyepiece that provides a crisp focus and a reasonably large field of view — allowing more flexibility when composing a photo. Pictured below are the vacuum pump and film holder.

Jack Schmidling Productions, 18016 Church Road, Marengo, IL 60152; phone, (815) 923-0031; fax, (815) 923-0032; e-mail, arf@maxx.mc.net; website, http://user.mc.net/arf/cam.htm. Standard Astrocamera: $155. Vacuum Film Holder: $55. Focusing Plate: $85. Vacuum Pump: 110V AC $50, battery $75.



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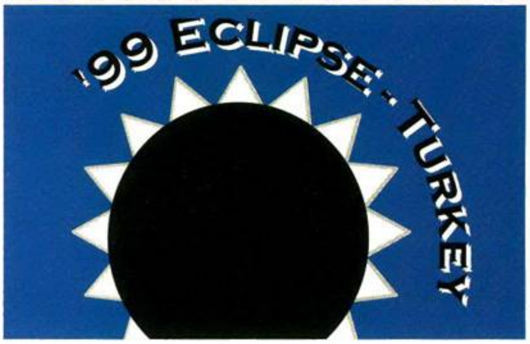

Eclipse Edge Expeditions

Nature's most awesome spectacle — a total solar eclipse — plus historic Turkey! Side trips to Europe. Hosted by astronomers for best eclipse view. Aug. 7-13. From $1850 pp. Extensions to Troy/Ankura/Turkish Riviera. Send for brochure + registr. forms or see <www.metaresearch.org/edge>

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Send a 9" x 12" S.A.S.E. with 4 stamps for complete catalog. Includes prices and description of **DELUXE CERTIFIED SCOPE PACKAGES** for Meade 7", 8", 10", LX10 , LX50 & LX200, as well as 12" LX200, and Celestron C5+, Celestar 8", Ultima 9¼", and Ultima 11".

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- **25% off Tuthill accessories when purchased with scope.**

Visit our showroom. We carry binoculars, Lumicon filters, JMI products, Tele Vue refractors, astronomy books, software, and ALL brands of accessories.

We clean and repair Meade & Celestron SCT's.

Meade 8" LX50 or Celestron Ultima 9¼" on Isostatic Equatorial Mount

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BYTES

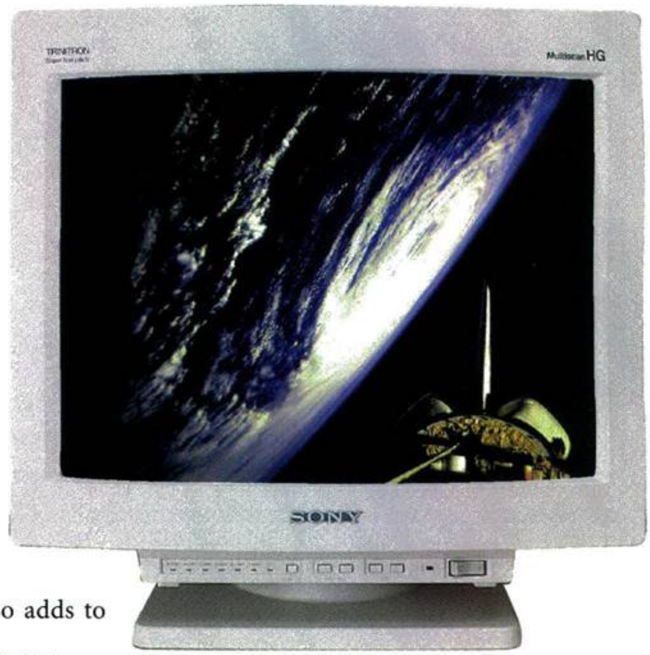
Earth: The Home Planet

▶ "For the first time in my life I saw the horizon as a curved line," says German astronaut Ulf Merbold. "It was accentuated by a thin seam of dark blue light — our atmosphere. Obviously this was not the ocean of air I had been told it was so many times in my life. I was terrified by its fragile appearance."

The unique beauty that is our home planet can be found in a new interactive CD-ROM from SynForest. The title, based on the best-selling photographic book *The Home Planet* by Kevin W. Kelly, features more than 120 stunning high-resolution images scoured from Soviet and American archives. Quotes from the Apollo, Soyuz, Mir, and space shuttle astronauts add narration.

The detailed images include tropical storms, the African desert, the Aurora Borealis, as well as the disk of Earth itself. These photographs offer a historical record of the planet's many "faces," and help to convey the grandueur of our "pale blue dot" in space.

Viewed with an interactive slide show, each image includes a caption and an in-depth text option. A 25-minute original music mix also adds to the experience.



Narrated NASA QuickTime movies are another feature to this package. They allow the viewer to relive some of history's proudest moments, including the launch of a Saturn V from Cape Canaveral, the first space walk, Neil Armstrong's first steps on the moon, and others.

SynForest, 2281 W. 205th Street, Suite 101, Torrance, CA 90501; phone, (310) 328-4464; fax, (310) 328-4414; website, http://www.synforest.com. Price: $29.99. Minimum system requirements: Windows — 486DX2 (50Mhz or higher), 8MB RAM for Windows 3.1, 12MB RAM for Windows 95/98, 24-bit monitor, 2X CD-ROM drive, Sound Board. Macintosh — 68040 processor, System 7, 32000 color monitor, 2X CD-ROM drive, 4MB free RAM.

The Webweaver Picks

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http://www.magnetars.com

http://solomon.as.utexas.edu/~duncan/magnetar.html

http://universe.gsfc.nasa.gov/SEU/news/1998/98-087.html

Astronomy & Cosmology
Information on the Big Bang, black holes, times warps, telescopes, software, and books. Also has links to other astronomy-related sites.
http://www.netlabs.net/hp/tremor/

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BOOKS

Comets: Creators and Destroyers

David H. Levy, 256 pages, Touchstone, New York, 1998; ISBN 0-684-85255-1; softcover, $12

▶ Comets were once seen as harbingers of death, portents of doom for ill-fated emperors. In the 4.6 billion years of their existence, these balls of frozen gases and water, some wider than a mile, have occasionally smashed into Earth — wreaking havoc and causing mass extinctions.

But comets have done a few good things as well. Many scientists believe they may have "seeded" the planets with the necessary ingredients to develop organic chemicals. These chemicals form the building blocks of life. By supplying such compounds, they could be responsible for our very existence.

In *Comets: Creators and Destroyers*, author David Levy looks at the role these dirty snowballs have played

COMETS
DAVID H. LEVY
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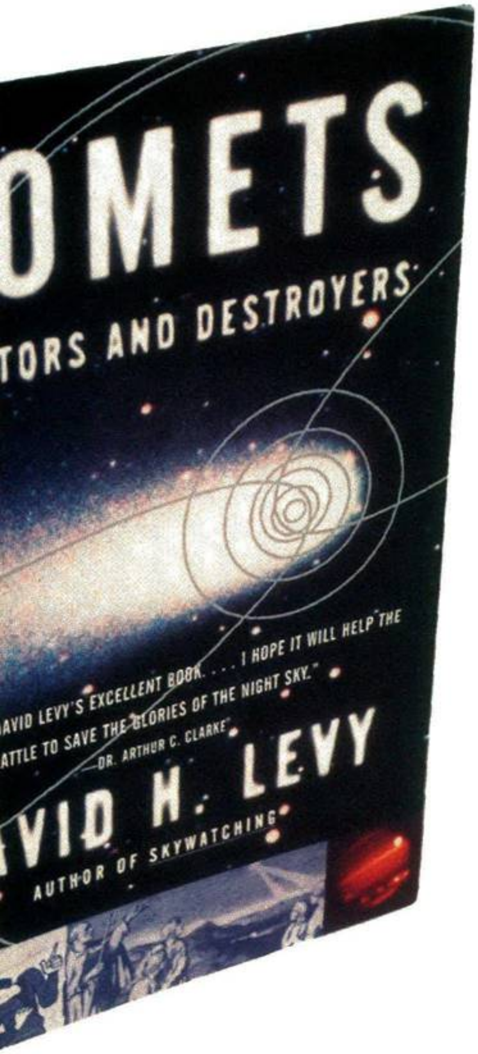
in shaping the chemistry, topography, and biology of the planets. Levy, who has discovered 21 comets and written 19 books, is dedicated to comet hunting. Though he calls comet hunting the "world's slowest sport," Levy centered his wedding reception around the viewing of a comet as well as an eclipse. His expertise, combined with his contagious, boyish enthusiasm, make him an excellent guide.

Levy introduces each chapter with epigrams from poets such as Shakespeare and Yeats, snippets of classic pulp fiction, or Beatle song lyrics. He ties the history of the solar system to the history of science with literary expressions. Levy clearly summarizes the basic principles of geology, cosmology, and paleontology. He traces the role of comets and asteroids as a major force in shaping the solar system, Earth, and life as we know it.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The book offers readers a comprehensive introduction to comets, which are some of the most fascinating objects in the solar system.

Comets were first studied by the Greeks. Aristotle thought they were "exhalations" originating in Earth's atmosphere. In 1556, Danish astronomer Tycho Brahe observed comets and concluded that they originated outside the atmosphere, beyond the moon. Brahe's conclusion was confirmed when Edmond Halley successfully predicted the return, in 1758, of the comet that now bears his name.

In 1986, a spacecraft measured Comet Halley's chemical composition. Hydrogen, oxygen, carbon, and nitrogen were found in proportions that are nearly identical to that of the human body. With this insight, scientists gained an understanding of the role comets may have played in the origins of life on Earth.

But as the book's title points out, comets are also destroyers. Levy provides readers with a vivid description of Comet Shoemaker-Levy 9's collision with Jupiter in 1994. He conveys his feelings of awe at the magnificence, while relating a sense of dread. Levy includes a hair-raising description of a similar impact on Earth: mile-deep craters, 500-foot tsunamis, air temperatures above 250°, and a worldwide smoke screen that lasts for months.

For the enthusiastic comet hunter, Levy's book is a must. He supplements many of his discussions with black-and-white photographs that appear, for the most part, clear and balanced in tone. A full bibliography at the back of the book provides readers with additional sources and a thorough index highlights important terms. The book inspires comet hunters to view the past, while looking forward as "night watchman," for Earth.

— Jake Miller

The Astronomy Cafe: 365 Questions and Answers From "Ask the Astronomer"

Sten F. Odenwald, 256 pages, W. H. Freeman and Co., 1998; ISBN 0-7167-3278-5, softcover, $14.95.

▶ This book comes out of Sten Odenwald's award-winning web site, *The*

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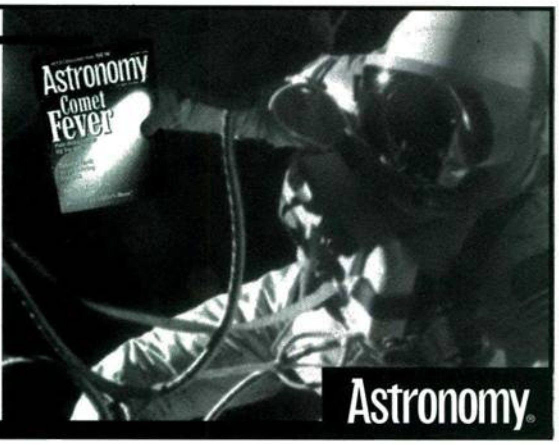

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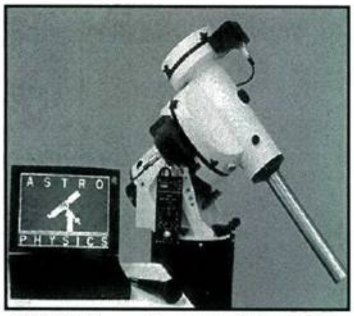

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Astronomy Cafe, and his role as the official know-it-all at NASA's web page, *Ask the Scientist*. Odenwald has taken the most popular questions he has answered through the end of 1997 and put them together in this book. You'll find answers arranged in chapters such as The Sun, The Planets, The Stars, Space Travel, Strange Sightings, and Telescope and Star Gazing. Twenty chapters in all address 365 questions — one for every day of the year.

The answers read a bit unevenly at times. But Odenwald points out in his introduction that this is intentional. He has geared each answer to the level of the question. And, in fact, some questions cannot be answered conclusively. Astronomers lack information in some areas and so concrete answers don't always exist.

The book is an easy read — practically a snack compared to that novel you're probably reading. You can browse through *The Astronomy Cafe* and hand pick the tastiest morsels. And then go back for seconds. Some of the dishes you might savor are, How thick are Saturn's rings? The answer: Some are only a few miles wide. In fact, "The thickness of the ring plane is deduced to be fewer than 100 meters, making the rings the thinnest object in the solar system." And you thought it was Cameron Diaz.

Another appetizer is, Is the expansion of the universe slowing down right now? The answer: Yes. "Astronomers are working hard to measure how rapidly the deceleration is happening to determine whether or not it will be large enough to cause a collapse of the universe in the future."

Odenwald is well equipped to answer these questions. He has 20 years of astronomical research experience and science education. He currently works on the NASA/COBE project, where he searches for traces of cosmic infrared background radiation.

If you're not yet sure about *The Astronomy Cafe*, the book, check out the web site. You can find it at http://www2.ari.net/home/odenwald/cafe.html. If you have a question of your own, ask the scientist himself at http://image.gsfc.nasa.gov/poetry.

— Tracy Staedter

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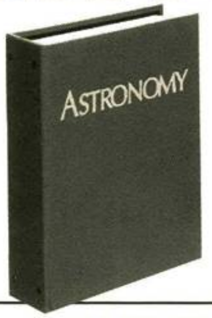

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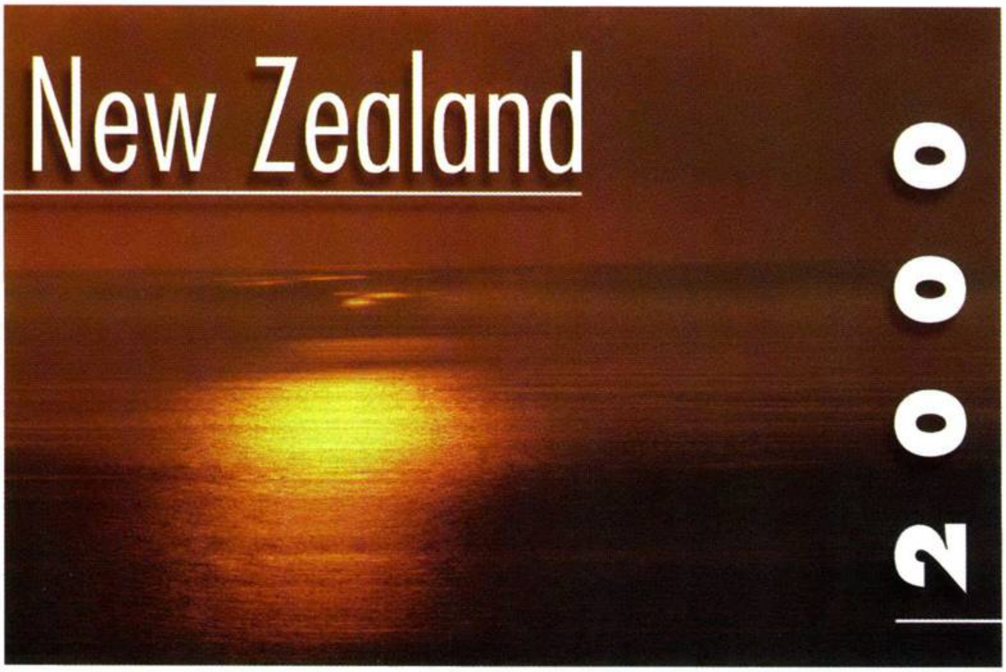

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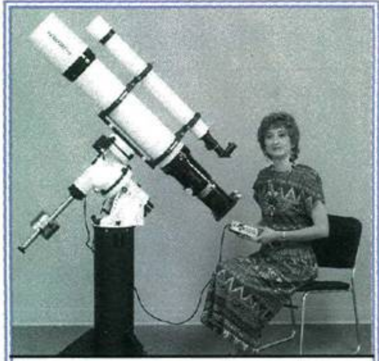

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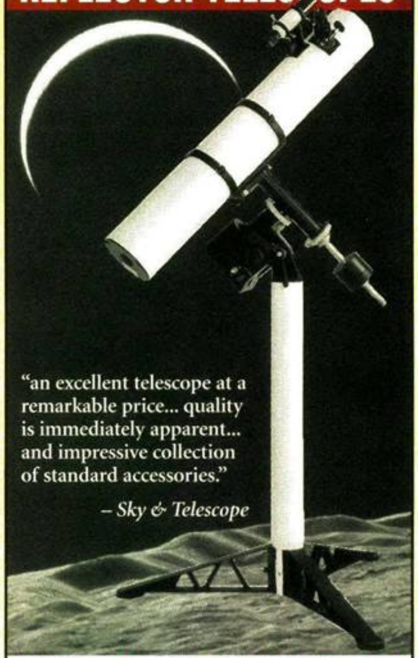

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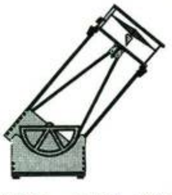

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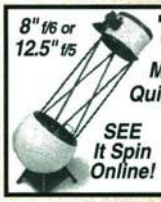

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LOOKING AHEAD

JANUARY

The 193rd **Meeting of the American Astronomical Society** will be held **January 5–9** at the Austin Convention Center in Austin, Texas. Topics to be discussed include extrasolar planets, the Hubble Space Telescope NICMOS instrument and how it is used in the search for planets, the dark mass in the center of the Milky Way, and afterglows of gamma-ray bursts. Further information can be found at the AAS website, http://www.aas.org.

For information on the **Winter Star Party** taking place **February 15–20** in the Florida Keys, check the WSP website at http://www.scas.org or call (904) 362-5995.

DECEMBER 16–19

Star Party

▶ Lake Kissimmee State Park, Florida. Sponsored by the Ridge Volunteer Astronomers and Lake Kissimmee State Park. Contact George Aycrigg, 14248 Camp Mack Rd., Lake Wales, FL 33853; (941) 696-3472; e-mail, gda@gate.net.

JANUARY 5–9

American Astronomical Society Convention

▶ Austin Convention Center, Austin, Texas. Hosted by the University of Texas at Austin. For information on scientific programming or exhibit information contact Diana Alexander, (202) 328–2010; e-mail, diana@aas.org; for registration information contact Millie Durbin, (202) 234-7850; e-mail, reg-help@aas.org; AAS website, http://www.aas.org.

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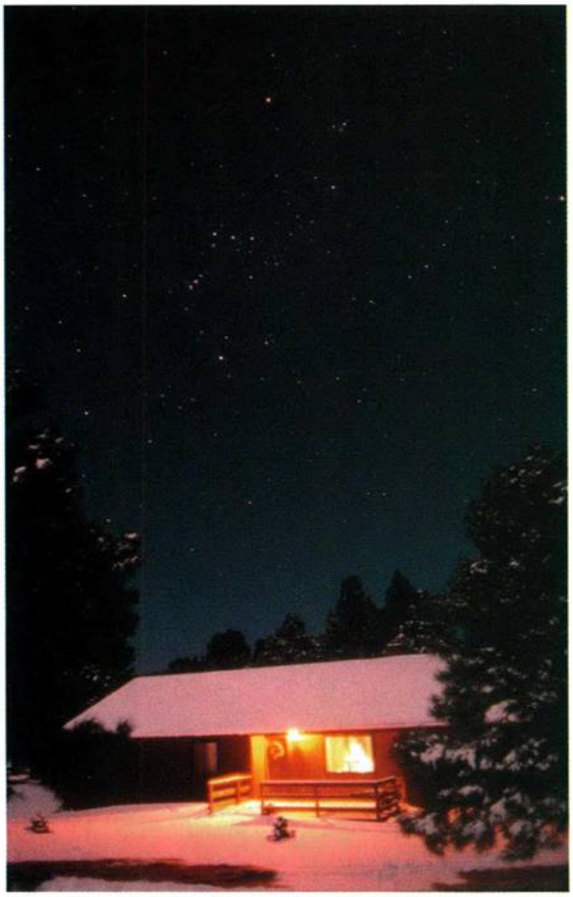
JANUARY 8, 15, 22, 29

Friday Star Nites

▶ The Hudson River Museum of Westchester, Yonkers, New York. January 8 – The Start of It All; January 15 – Follow the Drinking Gourd; January 22 – The Nine Planets; January 29 – Return to Mars. Contact Connie Cullen, Hudson River Museum of Westchester, 511 Warburton Avenue, Yonkers, NY 10701; (914) 963-4550; fax, (914) 963-8558.



The mighty hunter Orion overlooks this cozy winter scene in Mormon Lake, Arizona. Frank Zullo

JANUARY 14–18

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Northwoods Winter Starfest

▶ Hobbs Observatory, Beaver Creek Reserve, Fall Creek, Wisconsin. Sponsored by the Chippewa Valley Astronomical Society. Contact Ray Forsgren, 4856 Inlet Drive, Chippewa Falls, WI 54729; (715) 720-0226; e-mail, starman@discover-net.net; website, http://www.phys.uwec.edu/cvas/.

FEBRUARY 10–14

Orange Blossom Special Star Party

▶ Hickory Hill Observing Complex, Brooksville, Florida. Sponsored by the St. Petersburg Astronomy Club. Contact Dennis and Ellen Farr, 8811 West Broad Street, Tampa, FL 33615; (813) 884–9111; website, http://home1.gte.net/hoffmanc/index.html.

FEBRUARY 15–20

Winter Star Party

▶ Camp Wesumkee, West Summerland Key, Florida Keys. Sponsored by the Southern Cross Astronomical Society. Contact Fred and Lucille Heinrich, 6165 Wiggins Road, Live Oak, FL 32060; (904) 362-5995; fax, (904) 362-5996; e-mail, astargazer@AOL.com; website, http://www.scas.org. For information about accommodations call (800) FLA-KEYS.

CONTACT

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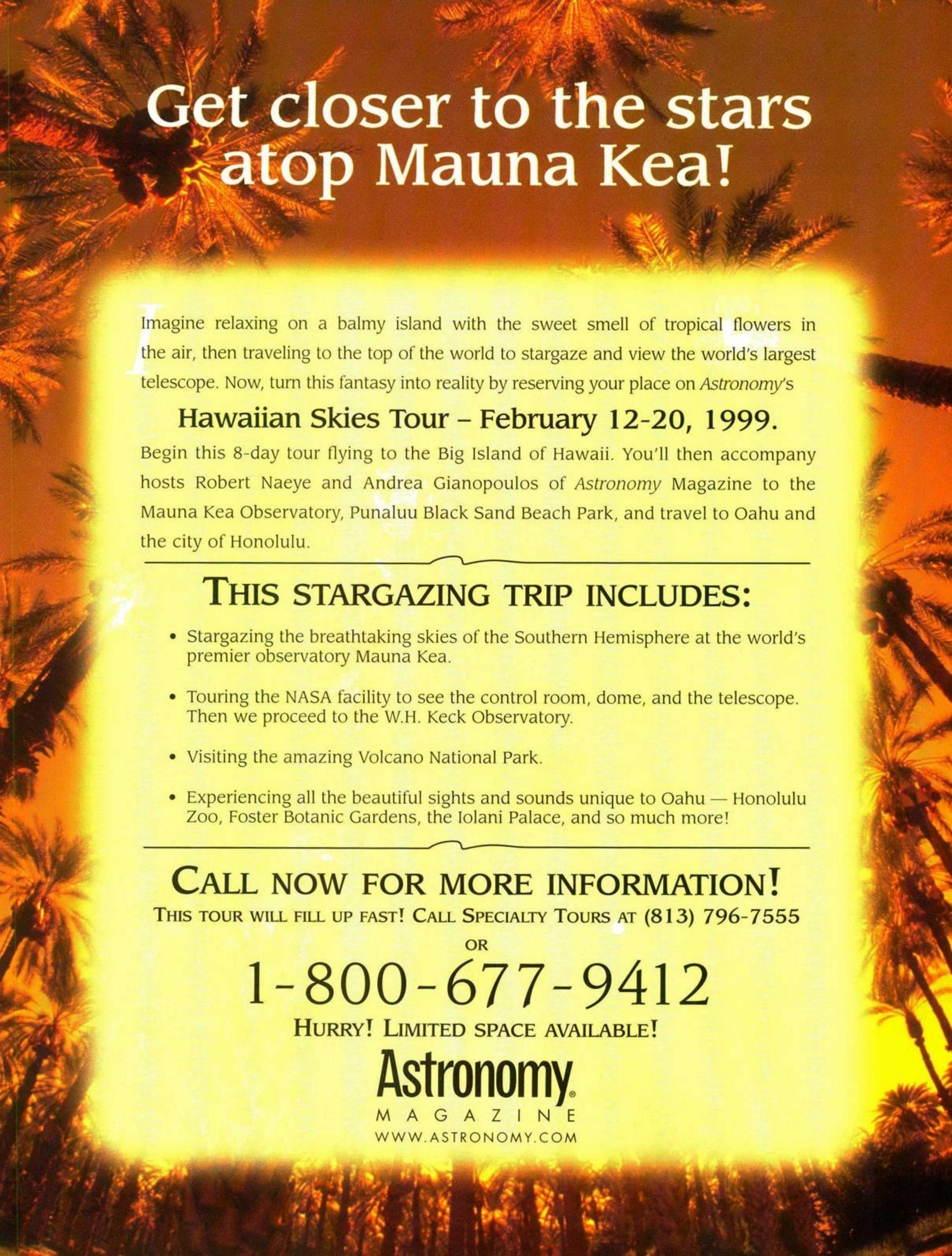

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Firstscope 114 Deluxe	**Call**
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Firstscope 80 W.A. Equat.	**Call**
Firstscope 70 Alt. Deluxe	**Call**
Firstscope 70 Equatorial	**Call**
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Item	Price
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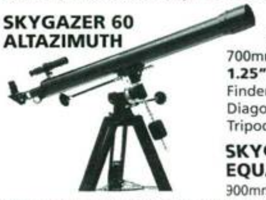

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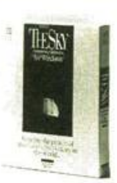

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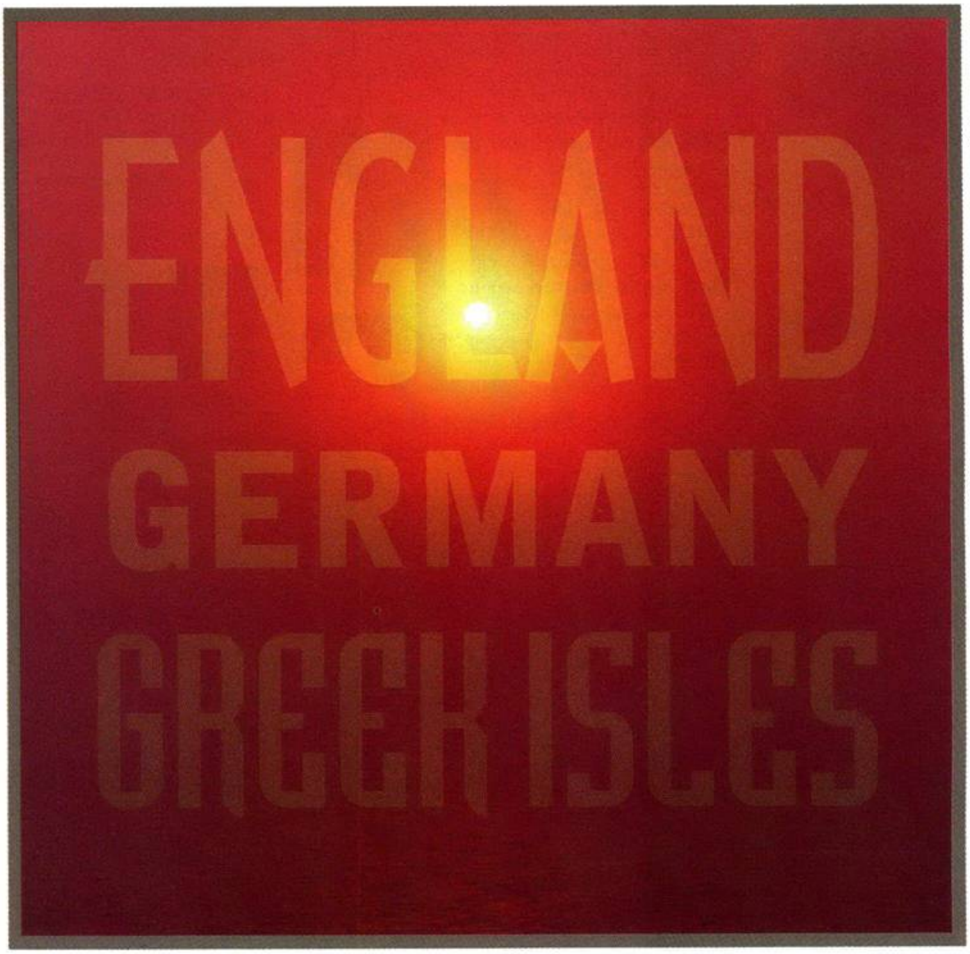

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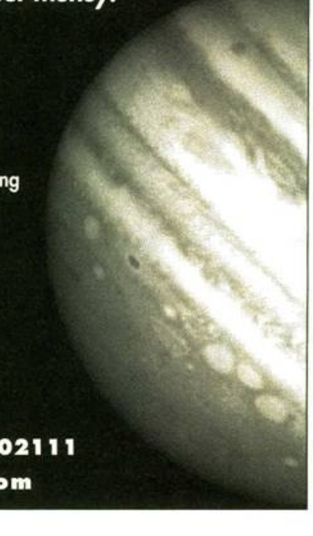

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OBSERVING HISTORY

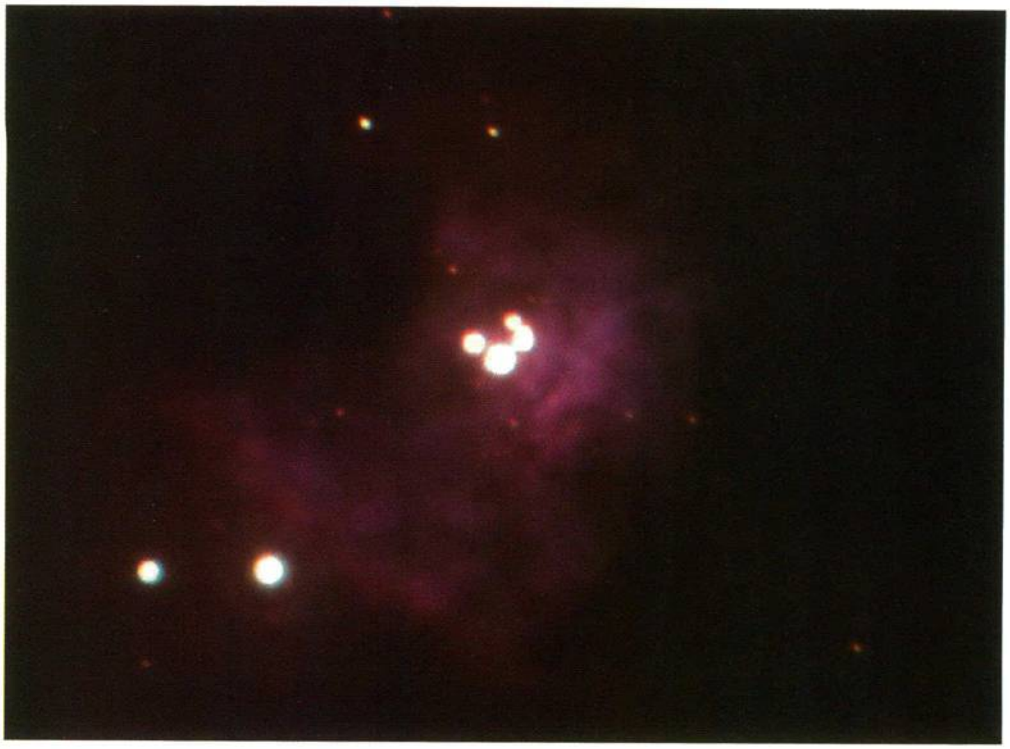
A Night on the Mountain

Spending a night on Kitt Peak comes with a new twist.

▶ Kitt Peak's granite towers 6,875 feet above the surrounding Sonora Desert. Although it contains little of mineral significance, the mountain is "Ioligam," the sacred dwelling of I'itoi, the Tohono O'odham Indian elder brother. It is also the site of Kitt Peak National Observatory and the National Solar Observatory, making it one of the best collections of telescopes on the planet. Together, these two divisions of the National Optical Astronomy Observatories (NOAO) comprise six major optical telescopes and five solar telescopes. The location was chosen for its high percentage of clear skies and excellent atmospheric transparency.

Kitt Peak has long been a hallowed site for amateur astronomers, but now they can do more than just see the big telescopes during the day. The advanced observing program at Kitt Peak allows amateurs to do astronomy on Kitt Peak using a dedicated telescope in a dome adjacent to the visitor center. We have participated in the program twice now, once in the spring and once in the autumn, and found it to be, as advertised, "the ultimate experience for amateur astronomers."

The program runs under the guidance of Adam



The Orion Nebula (M42)

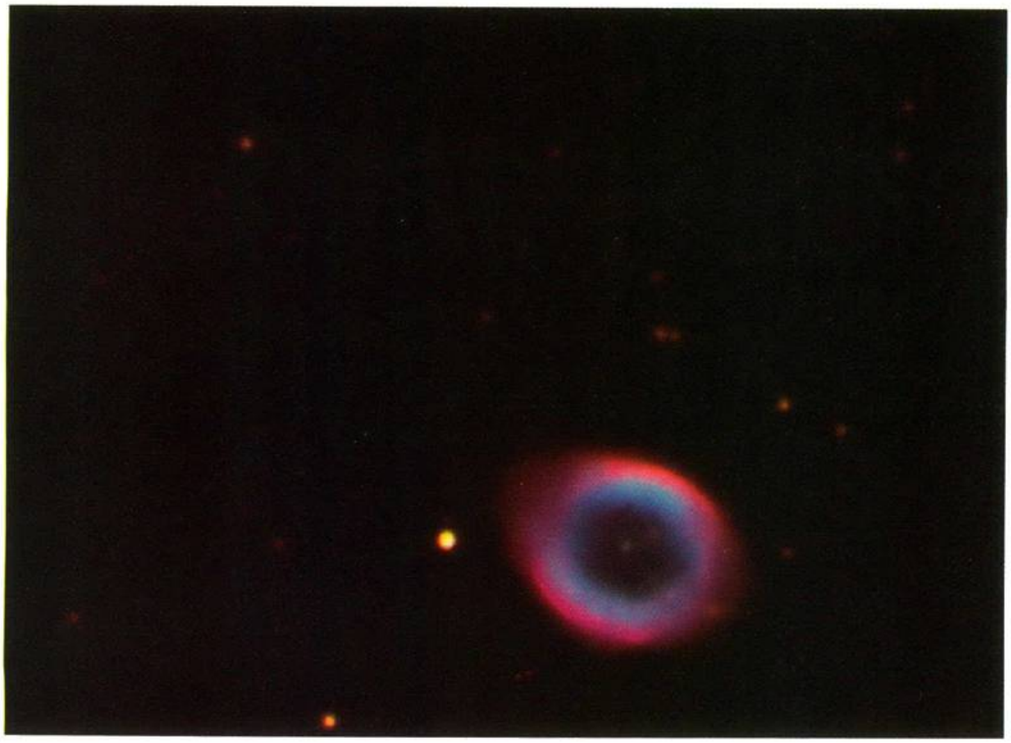
ROBERT LEVITT AND LONNIE BUSH

(16-inch f/10 SCT, ST-7 CCD camera)

The Ring Nebula (M57)

ROBERT LEVITT AND LONNIE BUSH

(16-inch f/10 SCT, ST-7 CCD camera)



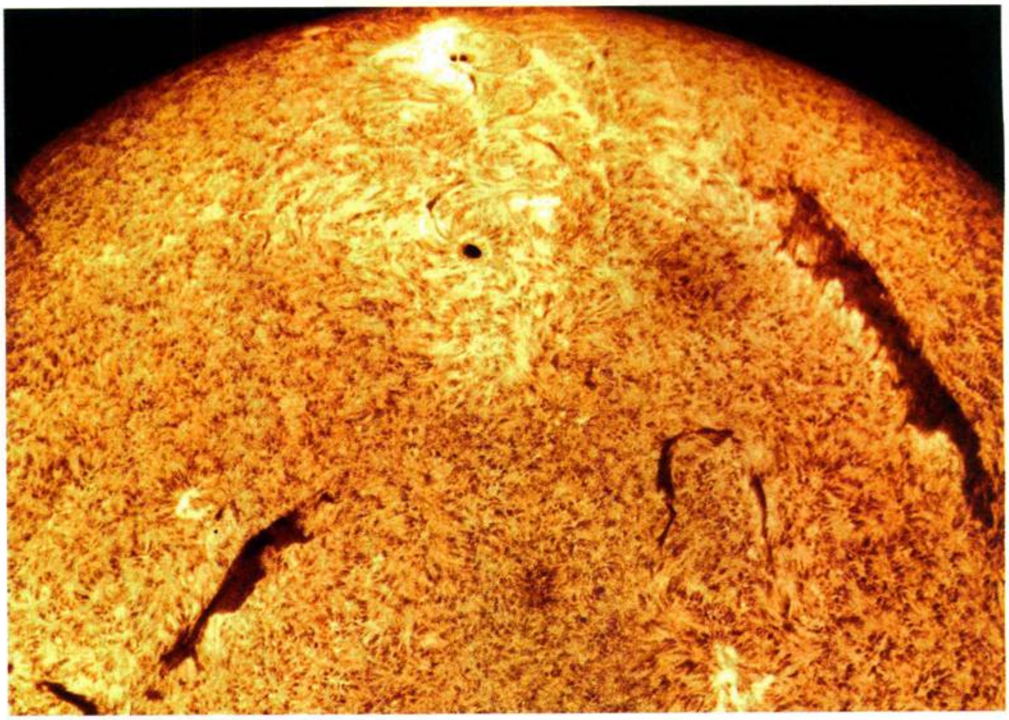
Block, the telescope operator and guide. The scope is a 16-inch f/10 Meade LX 2000 SCT equipped with an autoguider and a PC-controlled ST-7 CCD camera. Once you've paid the $250 per night fee, which may be split among two participants, the observational agenda is yours. You can do visual observing, conventional astrophotography, and/or CCD imaging, and the scope is yours all night — as long as you can stay awake.

We can't say enough about how special this will be for any amateur astronomer. But we can offer some tips for those who may be interested in the program. First, read the detailed description of the program at http://www. noao.edu/outreach/aop. This provides answers to frequently asked questions, resources, and equipment, available dates, and a gallery of recent images taken by amateurs. Block can be reached at ablock@noao. edu.

Remember that CCD imaging is much faster than conventional film. And consider that the public observing program reserves the dome for three hours after sunset, the dome obscures objects close to the horizon, and observations must be calculated in mountain time.

We suggest that participating in the advanced observing program on Kitt Peak will make memories that will last your whole life. We're lucky to have such an opportunity at one of the world's great astronomical institutions.

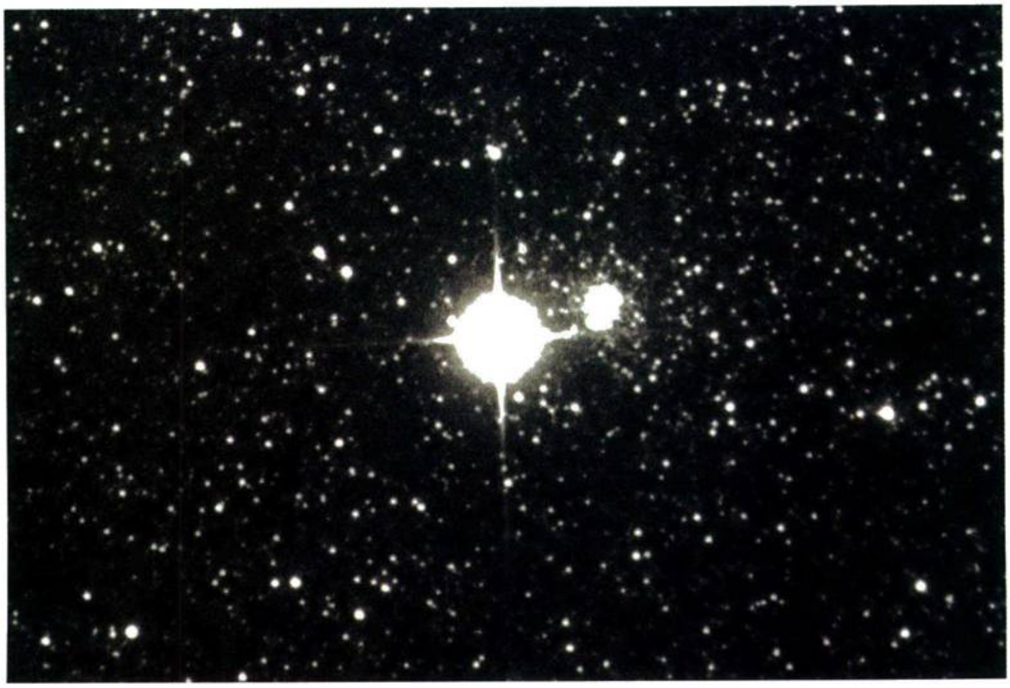
Robert Levitt and Lonnie Bush are avid amateur astronomers in St. Louis, Missouri.



The Sun's Disk in Hydrogen-Alpha

FRANZ KUFER

(5-inch refractor at f/17, Tech Pan film, Daystar 0.75 A filter, 1/15-second exposure taken November 3, 1990)



The Distant Globular Cluster Palomar 9

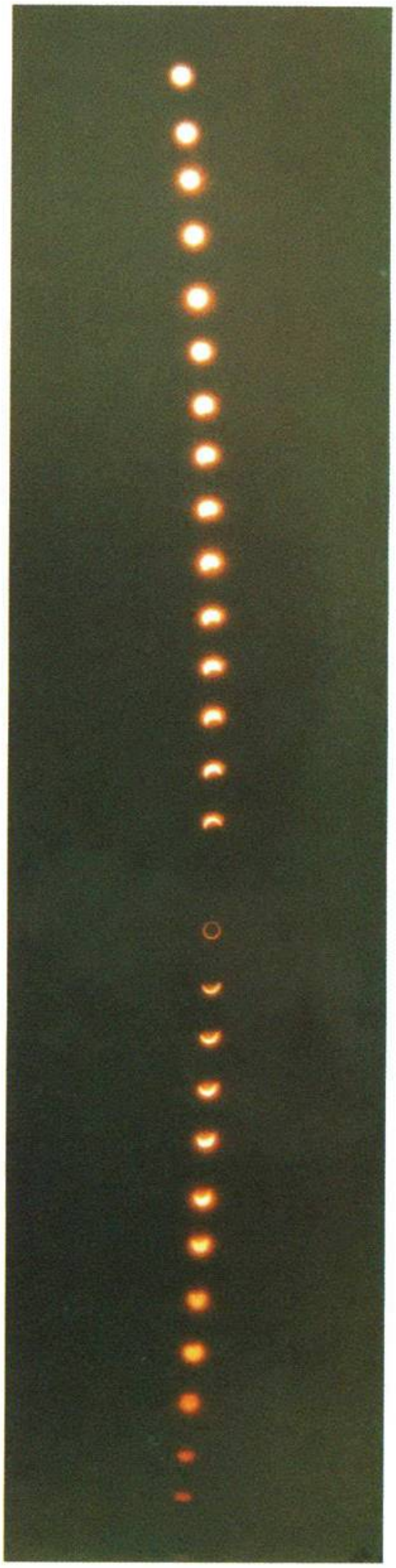
PRESTON SCOTT JUSTIS

(10-inch f/6 reflector, hypersensitized Tech Pan film, 80-minute exposure)

Orion's Many Colors

JOHN CHUMACK

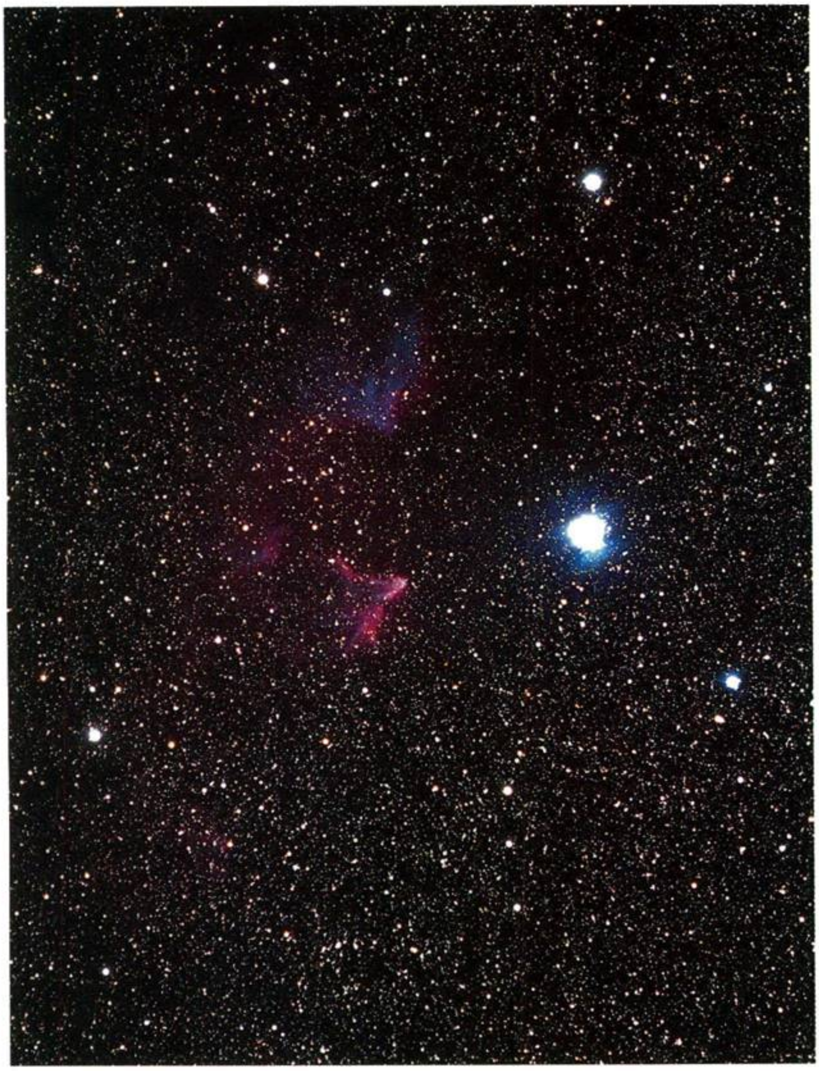
(80mm lens, medium format camera, Kodak 400 PPF film, 30-minute exposure)



Annular Eclipse over Pulau, Malaysia

JAMES KEVIN TY

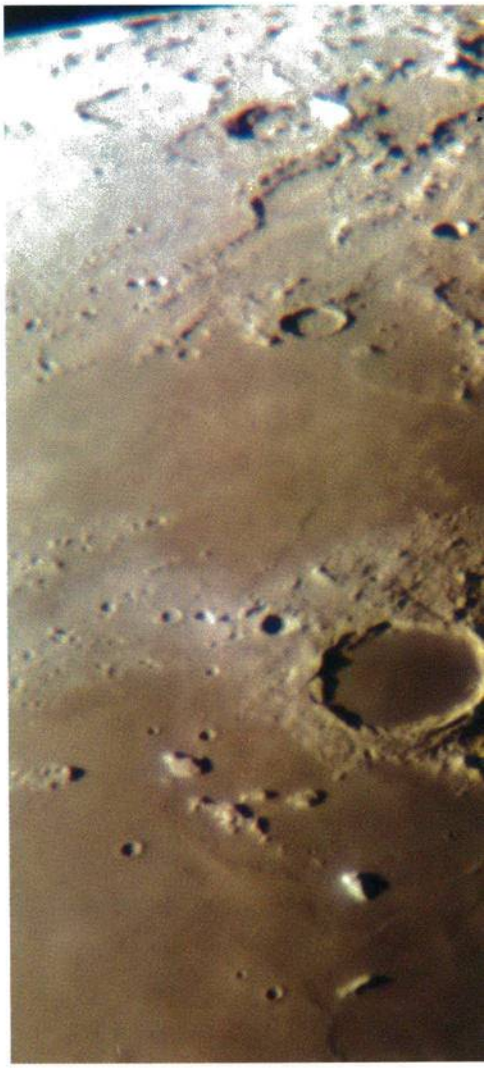
(28mm lens at f/11, Fujichrome 100 film, ND 5 filter, composite taken August 22, 1998)



Reflection Nebulae IC 59 and IC 63

GEORGE GREANEY

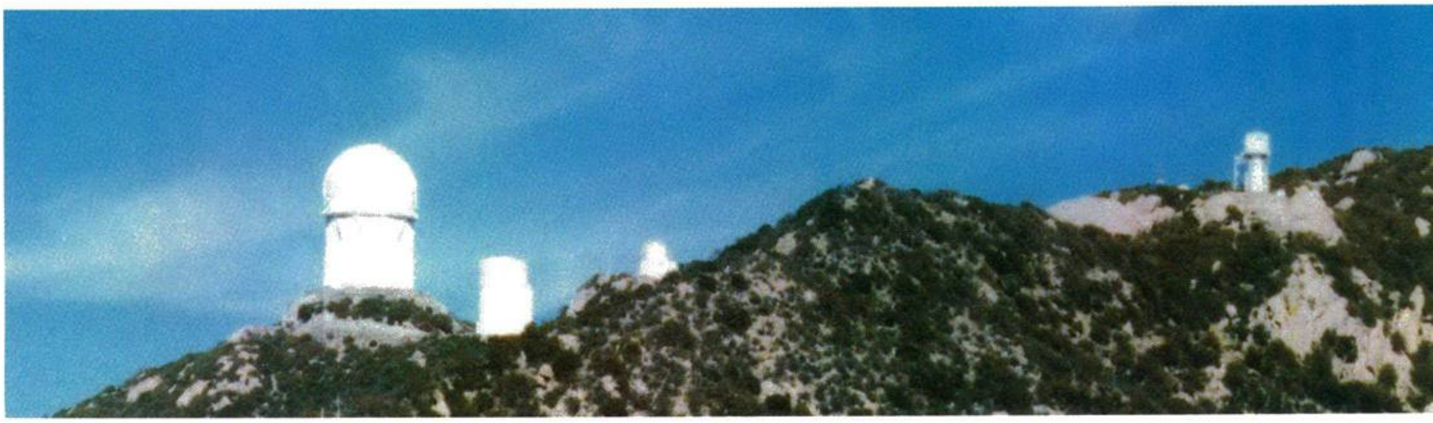
(6-inch f/7 apochromatic refractor, 120 format hypersensitized Kodak PPF 400 film, composite of two 45-minute exposures)



Lunar Crater Plato

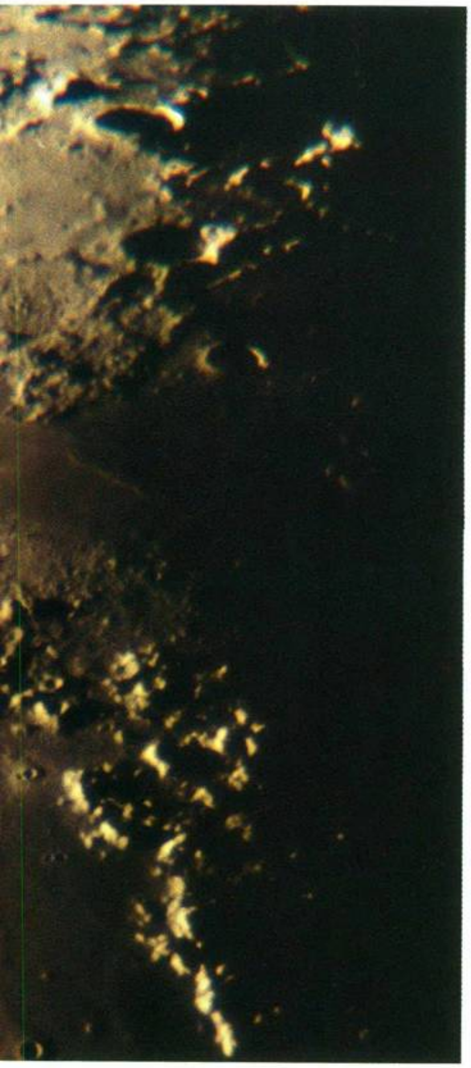
PHILIP A. TOREN

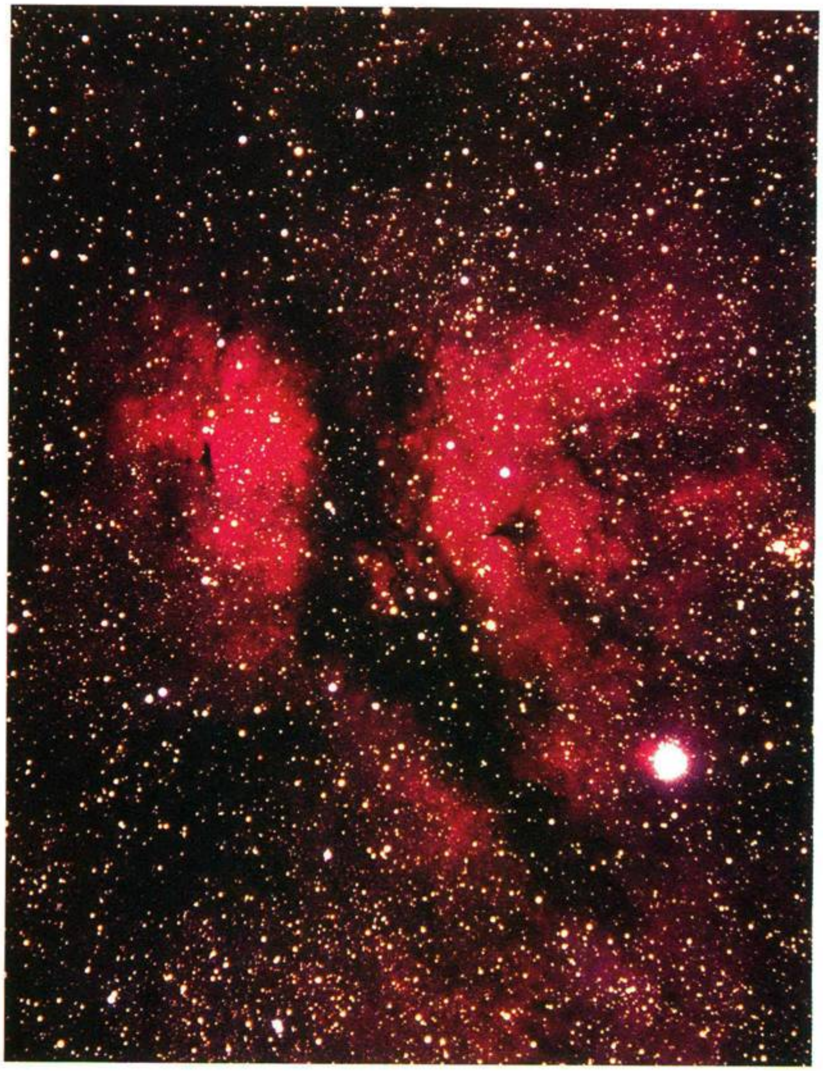
(6-inch apochromatic refractor at f/232, Kodak Royal Gold 100 film, 1-second exposure taken June 27, 1997)



Telescope Domes atop Kitt Peak

ROBERT LEVITT AND LONNIE BUSH



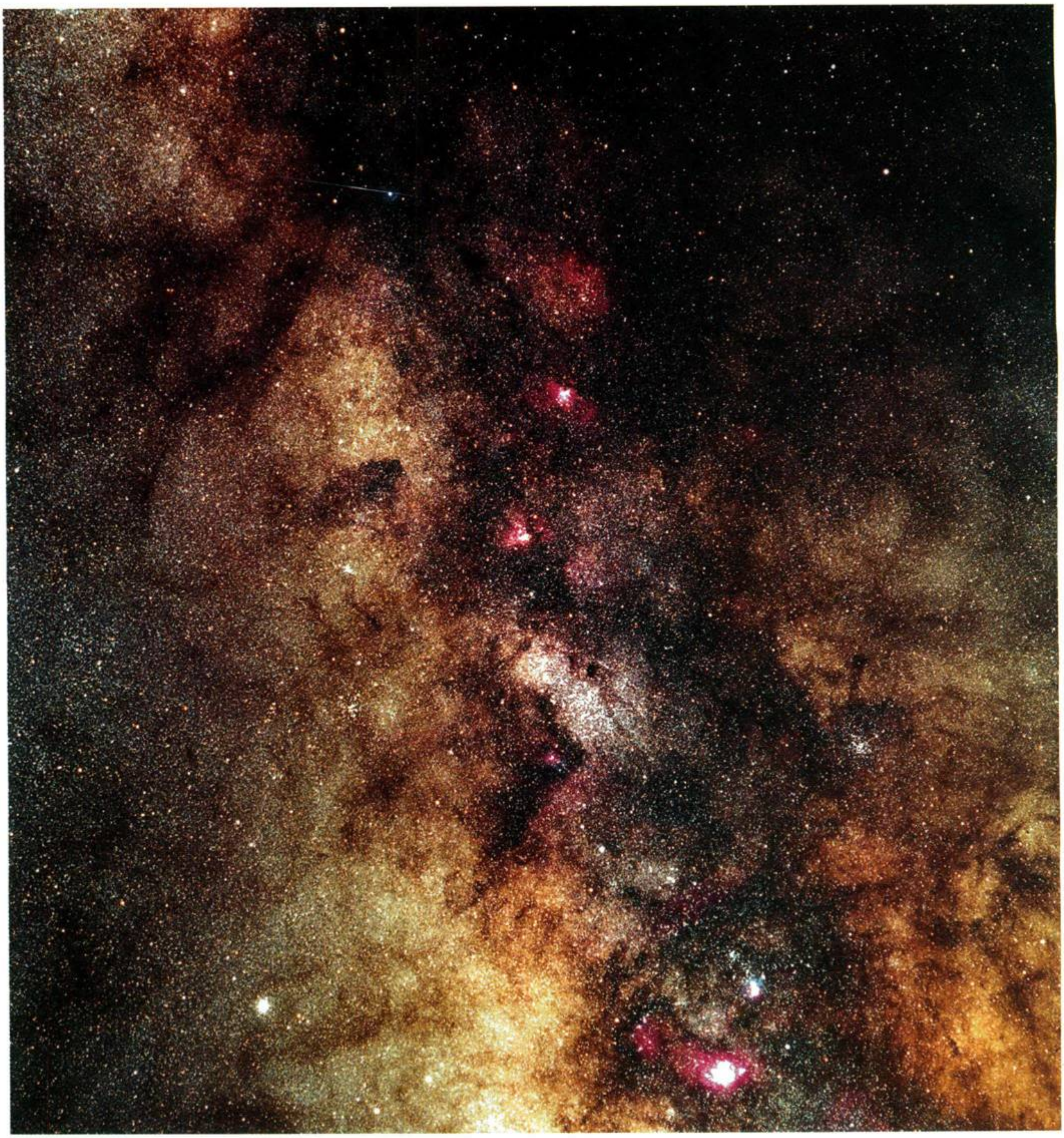


The Gamma Cygni Nebula (IC 1318)

CHRIS COOK

(3.3-inch f/7.8 apochromatic refractor, hypersensitized Kodak Pro 400 film, composite of three 45-minute exposures)

This month's best astrophoto



Galactic Center North

CARL AND CHRIS WEBER

(165mm lens at f/5.6, 6x7 camera, Kodak PPF Pro 400 film, composite of two 25-minute exposures)

The region slightly north of the galactic center holds myriad deep-sky objects such as the Lagoon and Trifid nebulae (near bottom), the Eagle and Omega nebulae (near center), the Sagittarius Star Cloud (below center), and the Scutum Star Cloud (top left). A meteor flashed through the scene during this exposure (left, above center).

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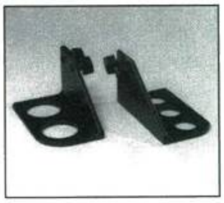

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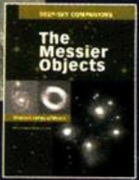

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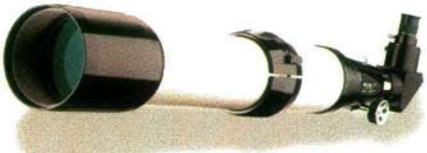

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Images by Jack Newton with the Meade 16" LX200 Schmidt-Cassegrain telescope, Meade f/6.3 Focal Reducer, and Meade Pictor 1616XT CCD Imaging Camera. *Clockwise from lower-left:* the Whirlpool Galaxy (M51); the Eagle Nebula (M16); Spiral Galaxy (M101) in Ursa Major; all exposure times: 5-mins. red, 20-mins. green, 40-mins. blue. The Dumbbell Nebula (M27); exposure times: 5-mins. red, 20-mins. green, 20-mins. blue.

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